Ōreti and Invercargill **catchment**

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SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

Ōreti and invercargill catchment

This document provides a summary of science information, opportunities for action, and socioeconomic context for the Ōreti and Invercargill (Makarewa, Waihōpai River, Waikiwi Stream, Otepuni Creek) catchment which drain into the New River Estuary.

This is one of twelve catchment summaries prepared for the Murihiku Southland region.

We have collated and presented scientific data at the catchment scale to provide an understanding of freshwater quality and quantity challenges and their underlying factors. We have included an evaluation of the current state of freshwater within the catchment and highlighted the magnitude of change necessary to meet freshwater aspirations.

Main features

Land area: 400,000ha

Major rivers and streams: Ōreti River, Makarewa River, Waihōpai River, Waikiwi Stream, Otepuni Creek, Kingswell Creek, Mokotua Stream, Waimatua Stream, Irthing Stream, Otapiri Stream, Bog Burn, Hedgehope Stream, Titipua Steam

Aquifers: Centre Hill, Five Rivers, Castlerock, Ōreti, Dipton, Lower Ōreti, Makarewa, Waihōpai and Awarua groundwater zones

Lakes: Lake Murihiku

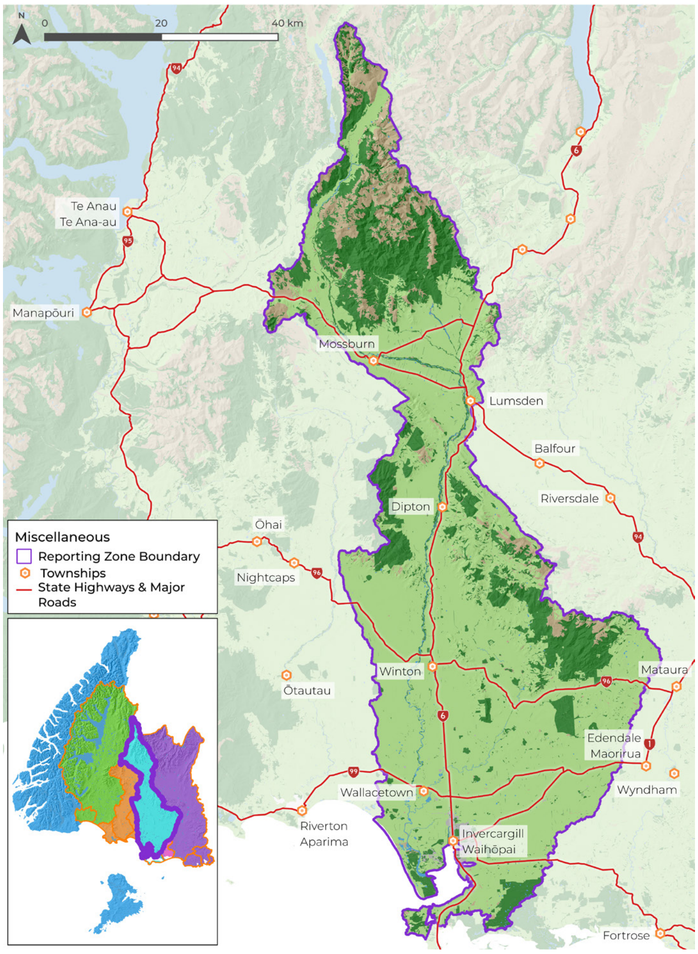
Estuaries: New River

Townships: Invercargill, Winton, Lumsden, Dipton, Mossburn

Population: Approximately 60,000

The information in this document should be considered alongside other information sources, including mātauranga Māori.

Catchment outline



For most attributes, current state is assessed using data from the 2018 – 2022 period.

Key messages

Issues

- Monitoring indicates that freshwater ecosystem health is poor in many parts of the Ōreti and Invercargill catchment. 10 of the 12 (83%) attributes presented here do not meet hauora targets, and 7 of the 12 (50%) attributes are graded as currently poor or very poor.
- The New River Estuary is in 'very poor' condition. Sediment and nutrients are the main ecosystem health issues. Sediment and nutrient accumulation from the catchment results in the growth of nuisance macroalgae and the development of eutrophic zones. Additionally, the wastewater discharge from the Invercargill treatment plant makes a large contribution to the nutrient-related issues in the estuary.
- Modelling indicates large contaminant load reductions are required to achieve desired freshwater and estuary outcomes. Waterbody load reductions are required for nitrogen (86%), phosphorus (86%), sediment (48%) and *E. coli* (89%).

Opportunities for action

- Implement property-scale mitigations and best possible management practices tailored to the specific agricultural system, physiographic characteristics of the land and the sensitivities of the receiving environments.
- Consider opportunities to facilitate land use change that reduces environmental impact or encourages deintensification to occur over time. This may be through developing long-term catchment plans and catchment projects, pilots and promotion of alternative land use options, or implementation of regulation.
- Catchment-scale mitigations, which could include restoration or creation of wetlands, riparian shading, stock exclusion and habitat retention that occurs at scale, large-scale detention bunds and edge-of-field mitigations.
- Remove nuisance macroalgae from new growth areas or in areas of high-value habitat such as seagrass and marshland, or on the fringes of current sediment deposition zones.
- Detect and remediate local point source contaminant discharges.
- Investigate actions to reduce or remove the contaminant load associated with Invercargill discharges to New River Estuary.
- Restore marginal vegetation (e.g. herb fields) and wetlands such as salt marshes and salt tolerant shrub banks, with special efforts in problem areas such as the Waihōpai Arm and Bush Point.
- The wider estuary would benefit from riparian planting, habitat improvement, establishing appropriate vegetated buffers, and addressing point source contaminant inputs.

Active restoration techniques like sediment and macroalgae removal will only improve the estuary's long-term condition if contaminant inputs are also reduced.

Socioeconomic context for action

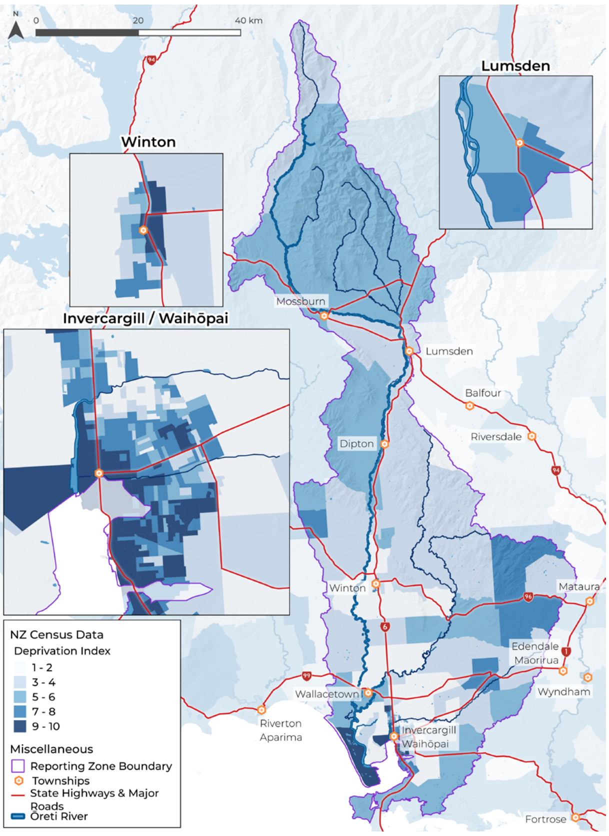
The Ōreti River and its associated waterways (Makarewa, Waikiwi, Waihōpai, and Otepuni) extend from Wrights Bush to Waimumu and from the mountains near the Mavora Lakes to the wetlands at Awarua Plains. Many communities and Census-based SA2s (statistical areas) are located within, or partially within, the catchment boundaries. This analysis is based on those SA2s with at least a third of their boundary within the catchment, or settlements with larger populations such as Lumsden Township.

The Upper Ōreti catchment contains Mossburn, Ōreti River, Winton, and Hedgehope SA2s, with an estimated population of around 8,000.

The upper catchment followed the general regional population decline from the 1990s and 2000s, caused in part due to neoliberal reforms and subsequent period of austerity in the farming sector. However, this period of depopulation was reversed in the upper catchment areas with coinciding increases in conversion to dairy farming through the 1990s and 2000s. This is a predominately rural area with around 30% of the total population directly involved in the agriculture, forestry, or fishing industries, with the exception of the Winton area, which is a service centre for the surrounding rural areas.

This area has broadly followed District demographic trends, with noticeably fewer younger adults, especially in the 20-24 age range, who often leave for further education and employment elsewhere. There is a slightly higher male-to-female ratio. Ethnicity trends and place of birth are similar to the District, with slightly fewer people identifying as Māori and a steadily increasing Asian population in the area, particularly in the Mossburn and Ōreti River areas. Deprivation levels in the upper catchment are mostly low to moderate, with small pockets of higher deprivation in parts of Winton and Lumsden townships.

Social Deprivation Index



Social Deprivation Index

The Deprivation Index measures socioeconomic deprivation based on census information. It considers income, income benefits, communication access, employment, educational qualifications, home ownership, care support, living space and living conditions.

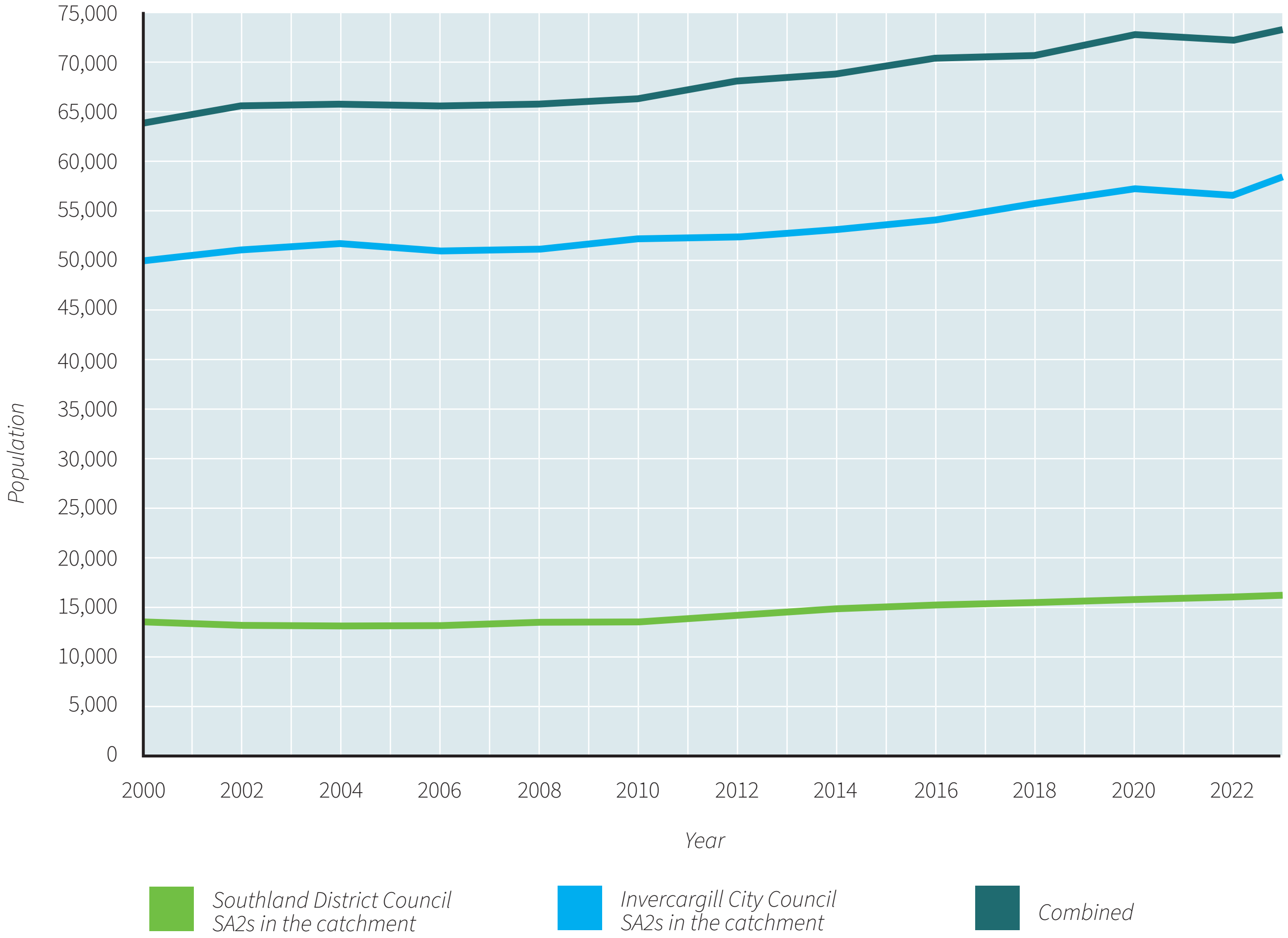
In the lower Ōreti, the statistics are taken from a combination of several Southland District Council areas and the majority of the Invercargill City Council area, except for Bluff and surrounds (an estimated combined total population of 60,000+). The population trends in both areas are very similar, with increases in population beginning from 2000 and some small fluctuations in the mid-2000s and 2020.

The areas within the Southland District Council boundary (such as Waianiwa, Grove Bush and Wallacetown) have an estimated total population of 6,000 people. Demographic patterns are similar to the upper Ōreti areas but with a slightly higher percentage of younger people aged between 10-19 and fewer people aged over 70.

The non-urban areas within the boundaries of Invercargill city (Kennington-Tisbury, Myross Bush, Otatara, West Plains, Woodend-Greenhills) have an estimated population of 9,000 people. This population has been steadily rising since 2000. There is a notably lower percentage of younger adults living in these areas, especially between the ages of 20-34, and higher percentage of people aged 45-69 in the area than in the Invercargill City Council area. Most of the population in these areas identifies as European, with lower percentages of Māori, Asian, and other ethnicities represented. With the exception of Woodend-Greenhills (particularly focused around Woodend), these are also some of the least deprived areas in Invercargill.

In line with recent housing trends in the Southland District Council area, rents are increasing, and home ownership generally decreases throughout the catchment. Interestingly, homeownership is lower in the upper catchment than in the lower catchment, which can be linked to the mobility of dairy farm workers who are transient and take up rent properties.

Estimated population trends (Dot Loves Data, 2024)



The Ōreti and Invercargill catchment is comprised of numerous statistical areas across two territorial authorities. Statistical areas may lay outside of the catchment. Therefore, this graph indicates general population trends across the entire statistical boundaries, not the catchment itself.

Given the large area of this catchment, deprivation levels can vary from low to high. The lower areas of deprivation are primarily rural areas with small farms and lifestyle blocks surrounding the main settlements of Winton and Invercargill (such as Otatara, Myross Bush, and Kennington-Tisbury). The areas of higher deprivation are located in urban suburbs of Invercargill and parts of Winton and Lumsden, with other higher deprivation levels recorded in tiny settlements such as Glencoe, Te Tipua, Dacre, and Ōreti Beach.

Summary

- The rural economy (and many associated urban industries) relies heavily on intensive lowland agriculture, which is susceptible to industry or regulatory changes.
- Higher deprivation levels in some urban and rural settlements could result in less resilience and poorer wellbeing outcomes for their communities.
- Lower education attainment levels in parts of the catchment may reduce the capacity to adapt to economic, technological, and environmental changes.
- Established catchment groups for the upper, mid and lower Ōreti, provide a support system for members and may facilitate adaptation to external pressures and challenges

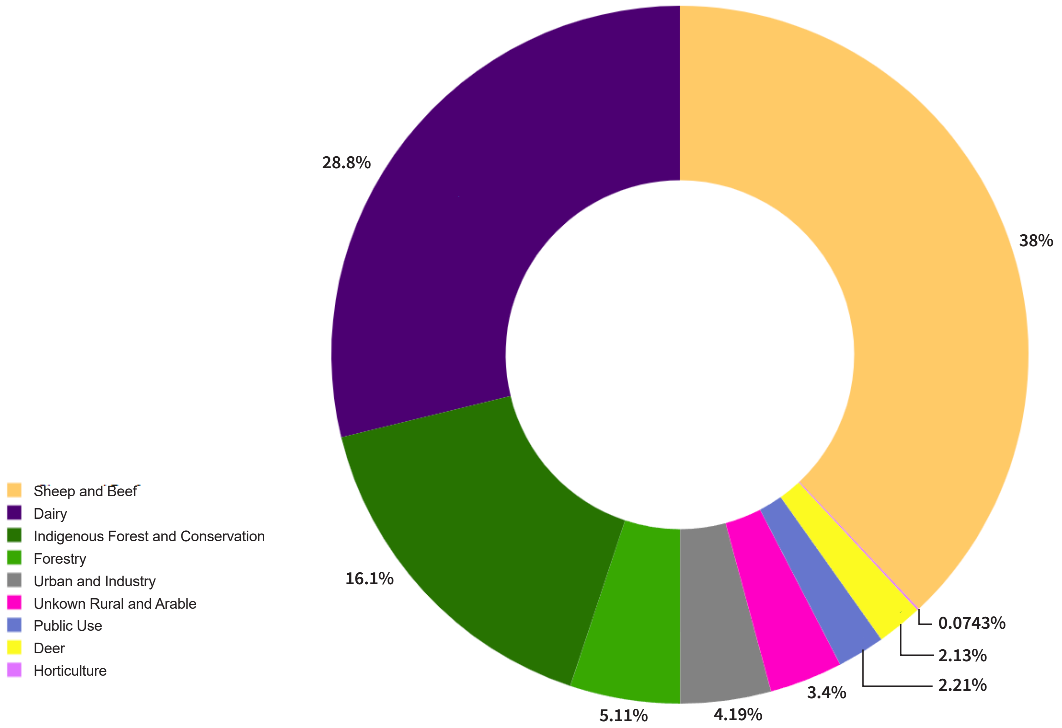
Catchment overview

The Ōreti and Invercargill catchment extends from the Thomson and Eyre Mountains east of the Mavora Lakes in northern Murihiku Southland to the New River Estuary at Invercargill city. The headwaters drain alpine, native tussock and forested land, while the mid and lower reaches drain largely pastured farmland on the plains. The towns of Mossburn, Lumsden, Dipton, Winton and Invercargill all lie adjacent to the Ōreti River.

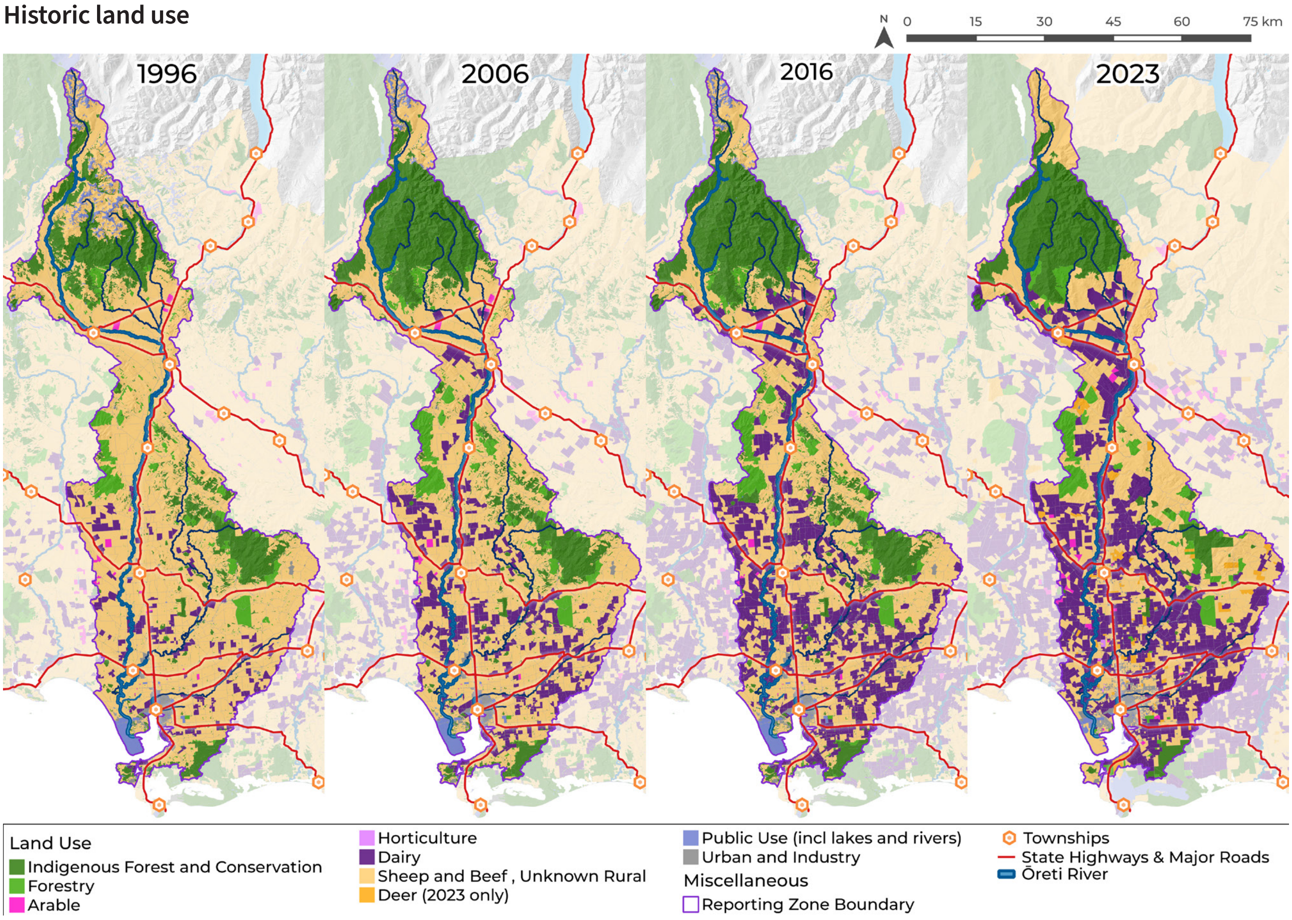
Land use

The Ōreti and Invercargill catchment covers approximately 400,000 hectares of land. Of this land area, approximately 67%, or 267,665 hectares, is used for various types of farming (including horticulture), 63,920 hectares of Department of Conservation land, 19,975 hectares of Forestry, and around 16,000 hectares classed as either urban or industrial, which includes Invercargill, Winton, and Lumsden.

There have been evdent changes in land use in the last 25 years. In particular, the map sequence below shows the growth of dairy farming in the catchment. While the change in total pastoral land area has been limited the growth of dairy farming has led to a large increase in agricultural land use intensity over this time. This has resulted in a large increase in contaminant loss and increased pressure on natural resources.



Historic land use



Please note that these maps and figures are indicative only due to land use class aggregation and differences in mapping methods.

Historic land use

	1996 to 2006	2006 to 2016	2016 to 2023	Overall 1996 to 2023
Pastoral land	↓ 7%	No change	↑ 9%	↑ 1%
Dairy	↑ 157%	↑ 84%	↑ 33%	↑ 532%
Drystock	↓ 19%	↓ 18%	↓ 3%	↓ 35%

Climate

Understanding climate at a catchment scale helps to explain spatial and temporal variation in landuse, water quality and quantity.

Current climate

The Ōreti and Invercargill catchment is typically considered to have a cool-wet climate. On average, the mean annual temperatures are in the range of 10-11°C, summer in the range of 12-15°C and winter between 3-6°C. Typically, the area experiences around 25-50 nights below 0°C annually.

Rainfall across the catchment is somewhat variable. The northern areas and headwaters receive higher annual average rainfall (1,500 – 4000 mm/yr) than the mid-reaches (1000 – 1,100 mm/yr). The lower reaches receive slightly higher annual rainfall (1,100 – 1,200 mm/yr). The average number of wet days per year (>1mm rainfall) ranges from approximately 130 per year in the middle catchment (Lumsden) to approximately 160 at the bottom of the catchment (Invercargill).

Future climate

Possible changes to the future climate of the Ōreti and Invercargill catchment have been explored through several scenarios based on the relative concentration pathways (RCP) of 4.5 and 8.5. The outputs from these scenarios are summarised in the table.

Precipitation

		RCP 4.5		RCP 8.5	
		Mid 21st century	End of 21st century	Mid 21st century	End of 21st century
Temperature	Daily mean (°C)	Increase 0.5-0.75°C in the mid and lower catchment, with 0.75-1.0°C in the upper catchment.	Increase of 1-1.25°C in the mid and lower catchment, with 1.25-1.50°C in the upper catchment.	Increase 0.5-0.75°C in the lower catchment and 0.75-1.25°C in the upper catchment.	Increase 1.75-2.0°C in mid and lower catchments, with up to 3°C changes in the upper catchment.
	Mean minimum (°C)	Increase by up to 0.5°C	Increase by up to 0.75°C for most of the catchment with up to 1.0°C in the upper.	Up to 0.5°C increase for most of the catchment, up to 0.75°C for the very upper.	Increase by up to 1.5°C for most of the catchment, with up to 2.0°C in the uppermost parts.
	Number of hot days	Increase by up to 5 in lower catchment, 10 in mid, and 20 in some of the more in-land areas	Increase by 10 in lower catchment, 15 in mid, and 25 in some of the more in-land areas	Increase by up to 5 in lower catchment, 10 in mid catchment, and 15 in some in-land areas.	Increase by up to 20 in lower catchment, 30 in mid, and 50 in some in-land areas
	Number of frosty nights	Decrease by 5 to 15 nights in the lower catchment and down by 20 in the upper catchment.	Increase by 0-6 days across the catchment, 10-20 days in parts of the upper-most catchment.	Increase by 0-6 days across the catchment, with 5-10 days in parts of the uppermost catchment.	Increase by 15-20% across most of the catchment with 20-30% increase isolated ares of eastern most and uppermost parts of the catchment.

		RCP 4.5		RCP 8.5	
		Mid 21st century	End of 21st century	Mid 21st century	End of 21st century
Rainfall	Annual rainfall change (%)	Increase by 0-5% in the lower and eastern parts of the mid/upper catchment, with 5-10% increases in mid-western portions and the upper catchment	Increase by 0-6 days across the catchment, 10-20 days in parts of the upper-most catchment.	Increase by 0-6 days across the catchment, with 5-10 days in parts of the uppermost catchment.	Increase by 15-20% across most of the catchment with 20-30% increase isolated ares of eastern most and uppermost parts of the catchment.
	Number of wet days	Decrease from 0-5 in lower catchment, and increase from 0-5 for mid and inland catchment	Increase of 5-10% annual rainfall, with a 10-15% increase for small parts of the uppermost catchment	Similar to RCP 4.5	Same as RCP 4.5 with small band in upper catchment with a decrease of 0-5 days per year.
	5-Day maximum rainfall (mm)	↑ 0-15mm	↑ 0-15mm	↑ 0-15mm	↑15-30mm in lower half, ↑0-15 in upper.
	Heavy rainfall days	Increase of 0-2		Similar to RCP 4.5	

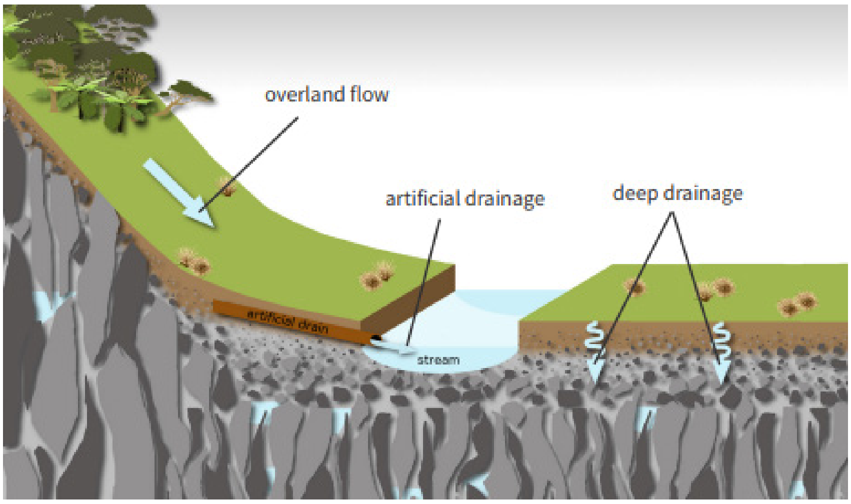
Catchment landscapes and hydrology

Water quality variations within a catchment are influenced by biogeochemical and physical processes. Understanding hydrology, geology and soil types within a catchment helps explain variations in water chemistry and water quality outcomes, independent of land use.

Headwaters

Rain falling in the headwaters of the Ōreti and Invercargill catchment makes its way down a gradient through scree slopes, tussock and native beech forest in the Thomson and Eyre Mountains. These headwater hills are characterised by thin forest and tussockland soils overlying sandstones, mudstones and semischists of the Caples Terrane.

Waterways in the headwaters are generally small in size (< order 4) with median flows less than one cumec.



Conceptual illustration of the typical landscape setting and contaminant loss/flow pathways in the upper catchment hill country areas.

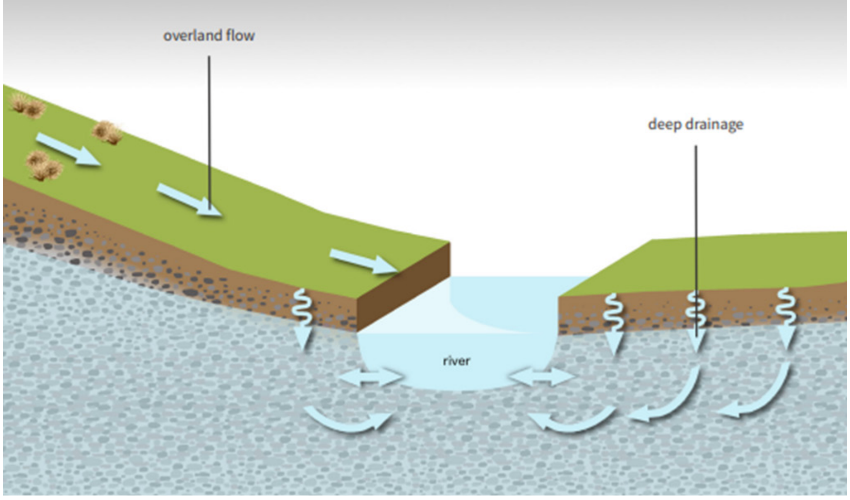
Relatively pristine water from the headwater hills flows to the bottom of the headwater valleys through recent alluvial gravel deposits. As water flows through these deposits, it mixes with localised recharge water from the surrounding land in the upper Ōreti Valley. Flow lag times in the upper catchment are relatively short (hours/days) with limited subsurface flow pathways and steeper topography.

As the proportion of land used for agriculture increases downstream, the river water begins to exhibit somewhat increased nutrients, sediment, and *E. coli*.

Mid catchment

As the Ōreti River flows across the Five Rivers Basin, it is joined by the Acton, Cromel and Irthing tributaries. These all drain the Eyre Mountains and carry relatively pristine water before flowing across the intensively farmed alluvial plains in this area.

Soils across the Five Rivers Basin are predominantly well-drained. Water moves easily through soils on the alluvial terraces, carrying nutrients into groundwater and connected streams.



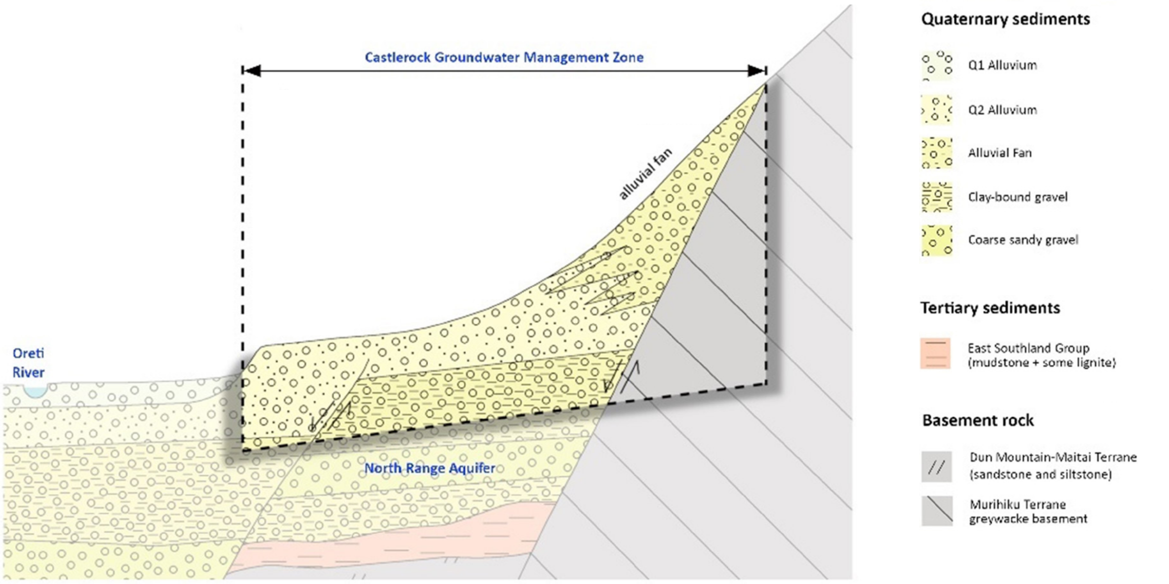
Conceptual illustration of the typical landscape setting and contaminant loss/flow pathways in the mid catchment.

Groundwater and river interaction is high along the river channels. Shallow water table aquifers are underlain by two confined systems, hosting highly utilised groundwater resources (the North Range and Lumsden aquifers). The river receives treated wastewater and stormwater from Lumsden via land discharge (indirect via infiltration to groundwater).

Flow pathways and lag times can vary greatly. Relatively long lag times (years) are associated with subsurface groundwater flows while the modified surface hydrology results in short lag times for overland flow and artificial drainage networks.

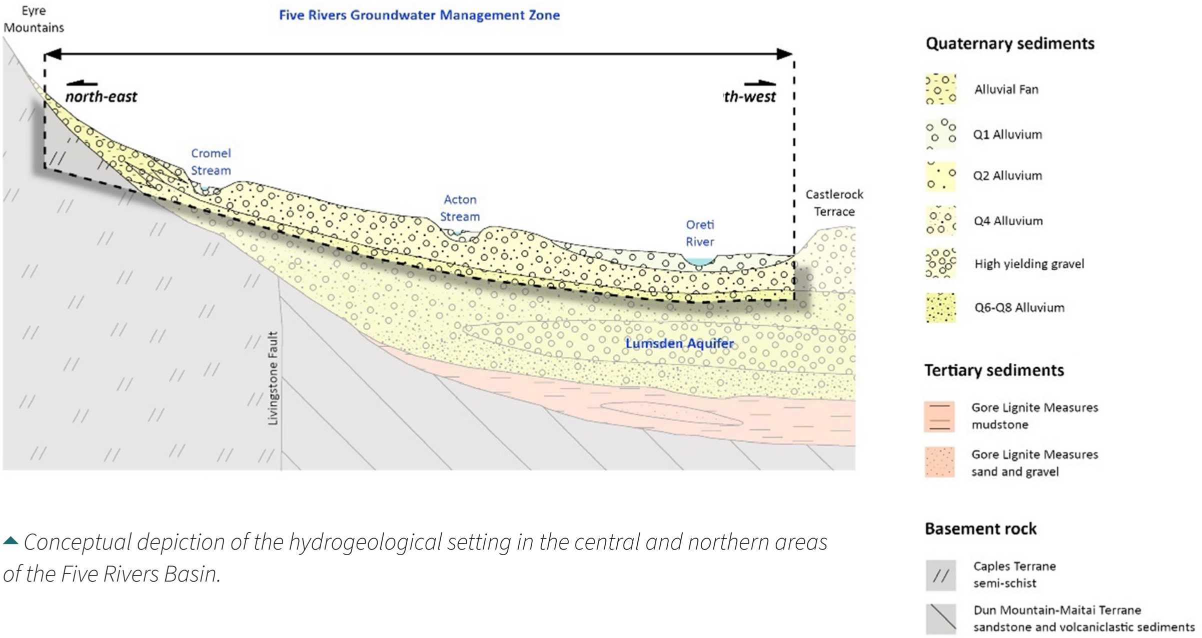
Downstream of Lumsden, the surface water and groundwater are funnelled through a notch in the Murihiku Terrane at Ram Hill.

Hydrological concept diagram



▲ *Conceptual depiction of the hydrogeological setting in the Castlerock area of the Five Rivers Basin*

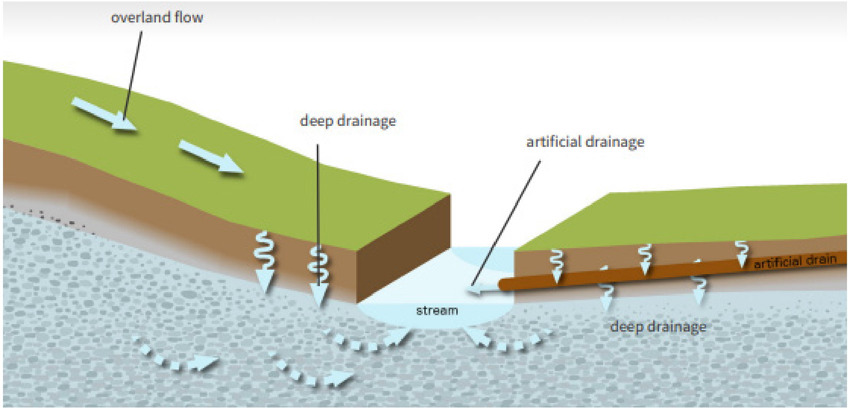
Hydrological concept diagram



▲ *Conceptual depiction of the hydrogeological setting in the central and northern areas of the Five Rivers Basin.*

Lower catchment

South of Ram Hill the Ōreti flows across alluvial outwash plains. Land adjacent to the river is characterised by intensive agriculture on well-drained recent soils, overlying recent alluvial deposits. These alluvial deposits are underlain by tertiary mudstone, sandstone, lignite and limestones of the Gore Lignite Measures and Winton Hill Formation.



Conceptual illustration of the typical hydrological and landscape setting in the lower catchment.

In the well-drained areas, dissolved nutrients are transported rapidly to groundwater and, subsequently, streams and the main river channel. Further from the river, older, more poorly drained pallic soils have formed from deposited wind blown sediment and are interspersed with gley soils in flood channels. The distribution of these soil types impacts the flow pathways water follows and the manner in which contaminants are transported. The land is often extensively drained, and waterways are modified to facilitate the rapid export of water to improve production. This modified hydrology efficiently carries agricultural contaminants to streams and the main stem river.

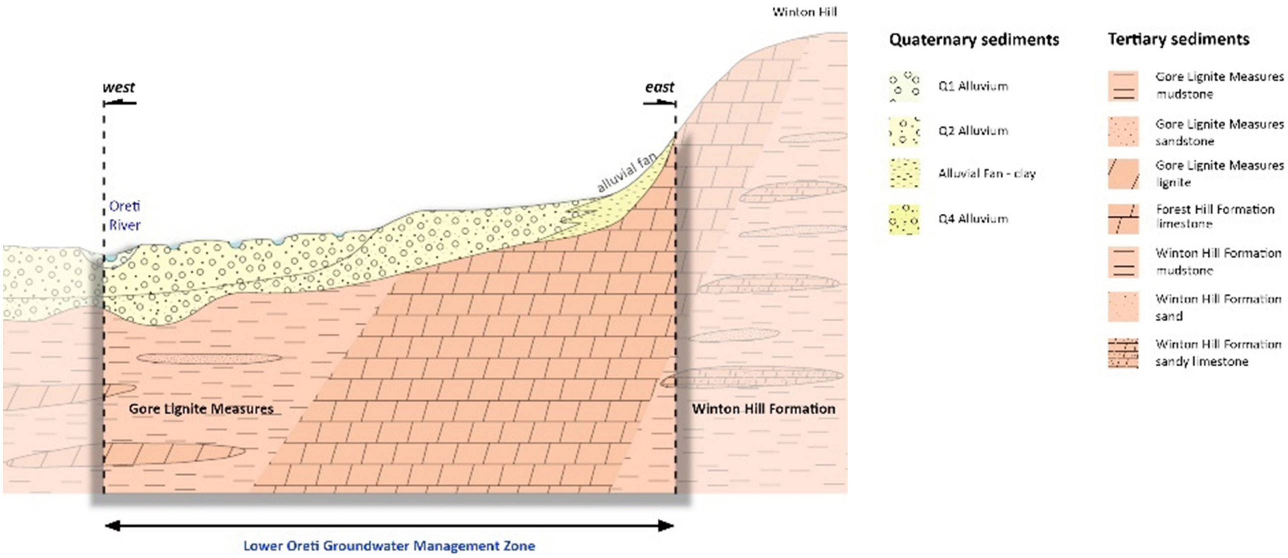
The river receives treated wastewater and stormwater from Browns, Winton, and Wallacetown.

The Ōreti is joined by the Makarewa River and Waikwi Stream south of Wallacetown. The Makarewa contributes approximately 15% of the Ōreti flow. The Makarewa and Waikiwi drain the Hokonui Hills and the extensive area of agricultural plains to the north and northeast of Invercargill. The Makarewa receives wastewater discharge from the Lorneville meat processing plant before it’s convergence with the Ōreti.

The Ōreti river starts to show signs of coastal influence around the Ferry Road bridge, where salinity starts to increase due to incoming tidal ocean waters.

The Ōreti terminates as it flows into the New River Estuary, which lies adjacent to Invercargill city. Here, the hydraulic conditions and tidal movement cause the deposition and accumulation of contaminants within certain parts of the estuary.

Hydrological concept diagram

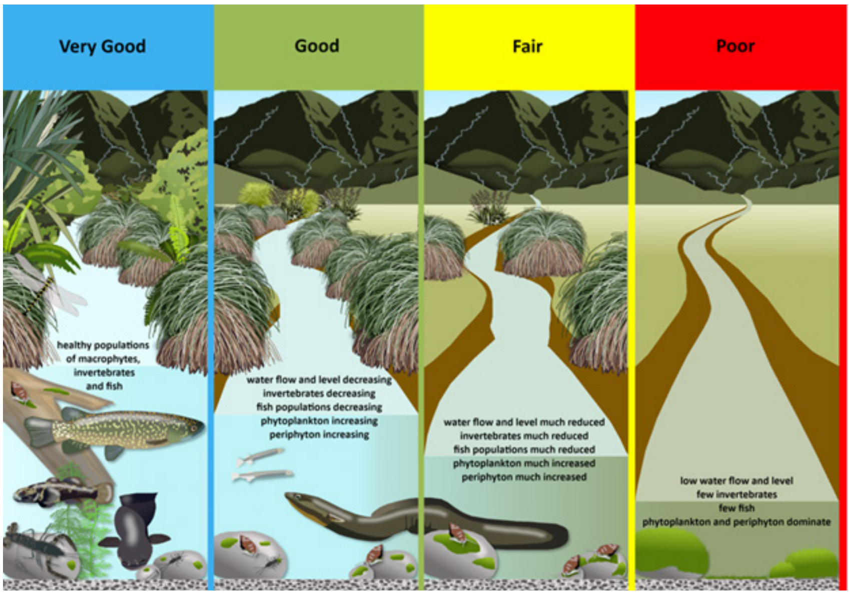


What are the water issues for this catchment?

Freshwater outcomes and how we measure them

Freshwater outcomes can be described from ‘very good’ to ‘poor’. This spectrum helps us understand the current state of the freshwater environment and what we might be trying to achieve in the future. The image below depicts this concept for rivers and streams.

Although many factors contribute to freshwater outcomes, we can only measure some of them to get an understanding of ecosystem health. We measure the aspects of the freshwater environment that can help us define and determine freshwater outcomes. These aspects are called ‘attributes’.



Attributes (the things we measure)

Attributes can relate to the ecosystem's physical or chemical environment or biological communities, such as periphyton, macroinvertebrates and fish. The measured state of an attribute tells us about some aspects of the environmental state, and together, they build a picture of the ecosystem's overall health. The more attributes we monitor, the more precise the picture can become.

Attributes may relate to ecosystem health or human health outcomes (e.g. *E. coli* or cyanobacteria concentrations). Some attributes are graded using ‘ABCD’ categories: A (very good), B (good), C (fair) and D (poor). In some cases, *E. coli* has an additional E (very poor) grade. Other attributes have simple ‘pass’ or ‘fail’ grades.

The more attributes with a higher grade, the better the overall ecosystem health. Conversely, when many attributes have poorer grades, the overall ecosystem health is poorer.

Hauora target attribute states

In 2020, Environment Southland and Te Ao Mārama Inc (TAMI) approved in principle the use of hauora as a freshwater target to be achieved within a generation. These targets provided the basis for the Regional Forum recommendations on how freshwater aspirations may be achieved.

The concept of hauora encompasses far more than the numeric attributes and targets described here. For simplicity, a reduced number of attribute states are presented in this document as they relate to ecosystem and human health. Hauora is a state of healthy resilience and is generally associated with the A 'very good' and B 'good' attribute states. However, attribute states that support hauora can be anywhere on the scale from A 'very good' to C 'fair', depending on the natural characteristics of that freshwater environment.

The natural characteristics have been differentiated through the use of classes.

We use monitoring results to compare the current attribute state with the hauora target state.

Streams and rivers

River classes

‘River classes’ group rivers (or parts of rivers) with similar characteristics. Similarities can include natural characteristics of the rivers, such as climate, gradient and flow.

The river classes used in Murihiku Southland are: Mountain, Hill, Lowland, Spring-fed, Lake-fed and Natural State.

About two-thirds of the rivers in the Ōreti and Invercargill catchment are classified as Lowland. The rest are Hill, Mountain, Natural State, and Spring-fed.

Target states can differ between attributes and between different river classes, which may have different target states for the same attribute.

Periphyton is an example of an attribute with different target states for different river classes.

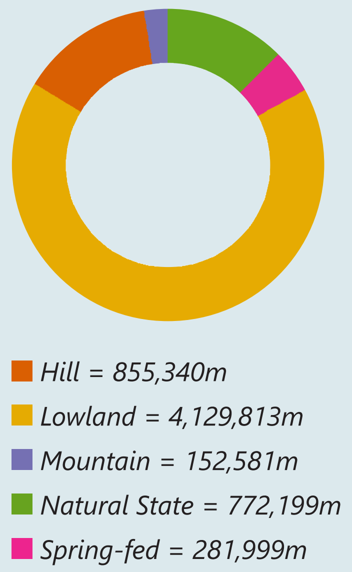
The different target states reflect the differences in natural characteristics for each river class.

- C target state: Lowland class
- B target state: Hill class
- A target state: Mountain, Spring-fed and Lake-fed classes.

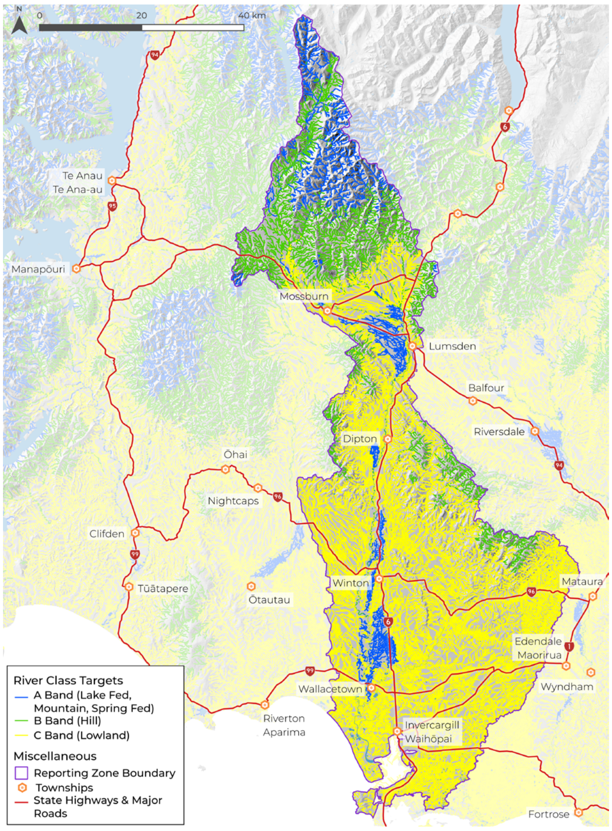
Natural State waterbodies can be identified for management purposes but are assigned attribute targets according to their underlying river classification (displayed here).

▸ *The map shows the distribution of periphyton targets for each river class within the Ōreti and Invercargill catchment.*

Length of river network in each class



River class hauora targets



Results for the river classes

Hauora targets and current states for ecosystem and human health attributes are summarised in the table below for the catchment’s Lowland, Hill, Mountain and Spring-fed river classes. Table colours correspond to the ‘ABCDE’ grading for attributes described previously. Results show that Lowland and Hill rivers in the catchment have the most water quality issues.

Current state is assessed using data from the 2018-2022 period.

	Lowland		Hill	
Ecosystem health attributes	Hauora target	Current state	Hauora target	Current state
Periphyton	C	C	B	A
Nitrate toxicity	A	C	A	B
Ammonia toxicity	A	B	A	A
Suspended fine sediment	C	D	C	A
Macroinvertebrates (MCI, QMCI)	C	D	B	C
Deposited fine sediment	A	B	A	A
Dissolved reactive phosphorus	B	D	B	A
Water temperature (summer)	C	D	C	C

Human contact attributes				
Benthic cyanobacteria	A	A	A	B
E. coli	A	E	A	D
E. coli at primary contact sites	A	D	A	D
Visual Clarity	B	D	B	A

	Mountain		Spring fed	
Ecosystem health attributes	Hauora target	Current state	Hauora target	Current state
Periphyton	A	A	A	-
Nitrate toxicity	A	A	A	-
Ammonia toxicity	A	A	A	-
Suspended fine sediment	A	A	B	-
Macroinvertebrates (MCI, QMCI)	B	B	B	D
Deposited fine sediment	A	A	A	-
Dissolved reactive phosphorus	A	A	B	-
Water temperature (summer)	B	C	B	-

Human Contact Attributes				
Benthic cyanobacteria	A	A	A	-
E. coli	A	A	A	-
E. coli at primary contact sites	A	-	A	-
Visual Clarity	A	A	A	-

"-" data not available.

Results for streams and rivers monitoring sites

Ecosystem health

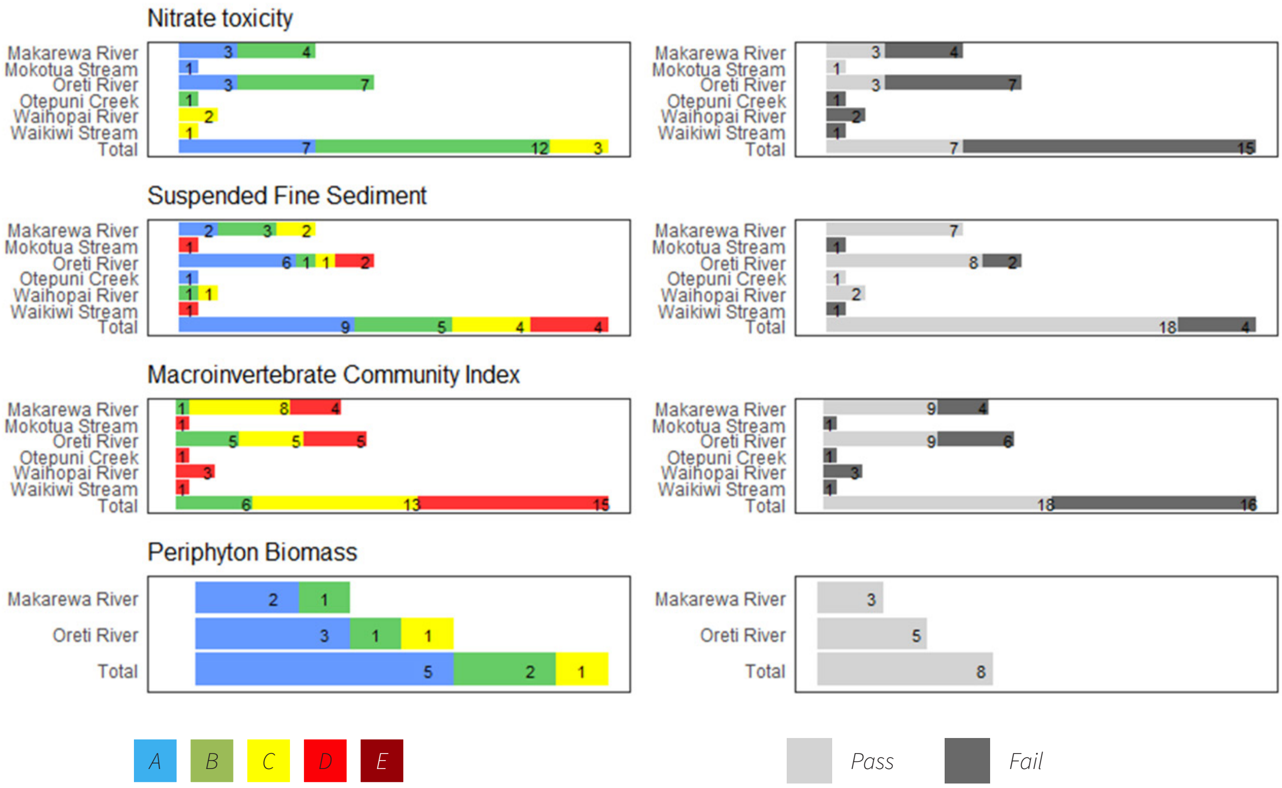
Results are given below for nitrate toxicity, suspended fine sediment, macroinvertebrate community index, and periphyton biomass. The number of sites that meet hauora targets are also provided.

Nitrate toxicity ranges from very good to fair state, with about a third of monitored sites achieving the hauora target.

Suspended fine sediment ranges from very good to poor, and only four sites do not meet the hauora target.

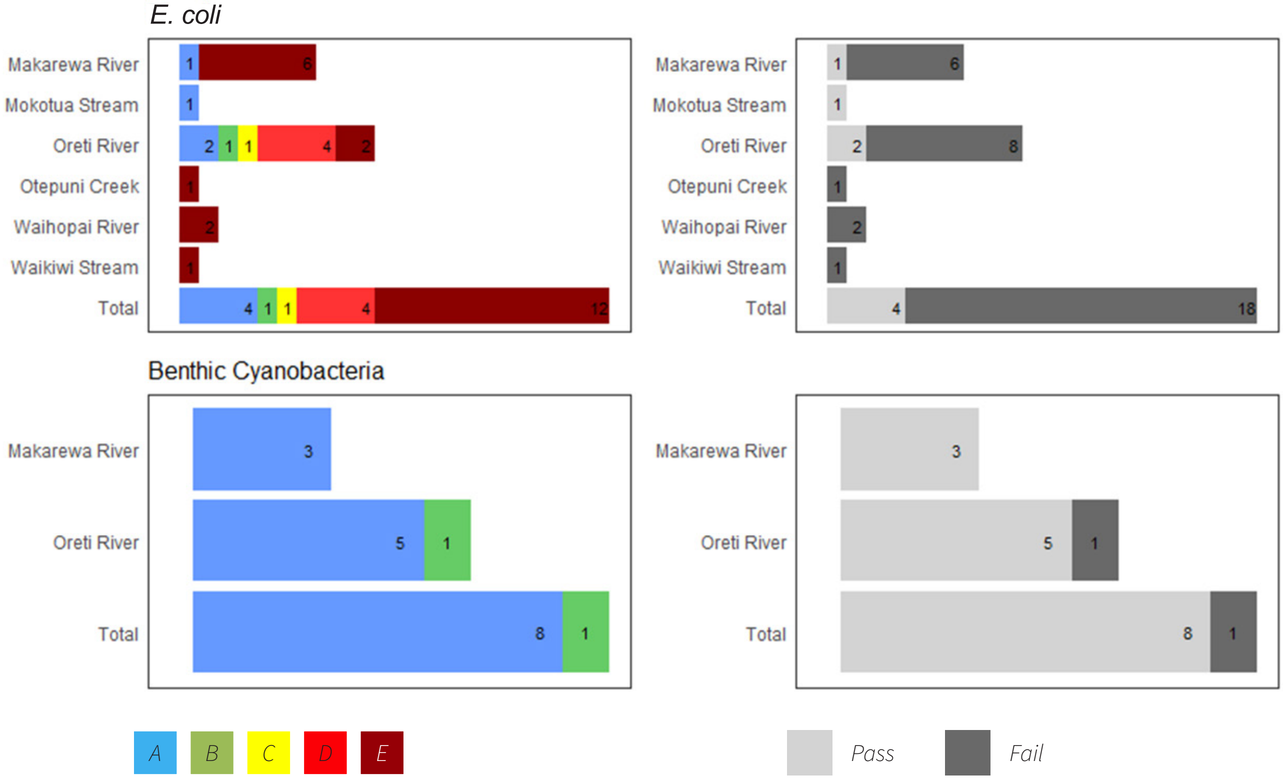
MCI ranges from good to poor, with the hauora target achieved at slightly over half of the sites. Periphyton ranges from very good to fair, and all sites achieve the target state.

Dissolved Inorganic Nitrogen (DIN) is similar to nitrate toxicity, although the bands are set lower than for nitrate toxicity to recognise that nitrate has effects, such as promoting excessive plant growth, before it reaches levels that are toxic to aquatic life. Dissolved reactive phosphorus (DRP) is another nutrient that can support excessive plant growth. DIN is in fair or poor state throughout the Ōreti and Invercargill catchment, with exceptions at four specific sites where it is very good, while DRP is very good except in lowland rivers and streams, where it ranges from good to poor.



Human health/contact

Only four sites in the Ōreti and Invercargill catchment meet the target state for *E. coli*. Most or all sites in the Makarewa River, Ōreti River, Otepuni Creek, Waihōpai River, and Waikiwi Stream have poor or very poor states for *E. coli*. Benthic cyanobacteria is monitored at eight sites in the Makarewa and Ōreti River sub-catchments, and the target state is achieved at all except one site, indicating that at most monitored sites, recreational use is not limited by excessive benthic cyanobacteria.



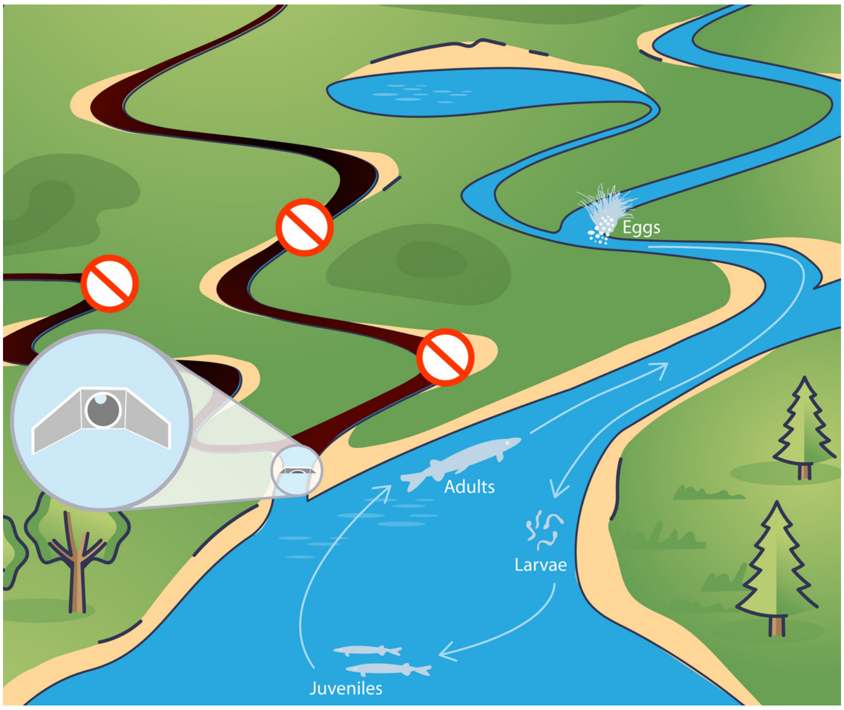
Fish passage

Fish passage barriers obstruct the passage of fish species. This particularly impacts migratory fish species that complete their lifecycles in both freshwater and the ocean, such as tuna/eels, kanakana/pouched lamprey and migratory galaxiids/whitebait. Generally, the closer a barrier is to the coast, the larger the area of habitat that becomes inaccessible to migratory fish, making it a higher priority for restoring passage. Common examples of fish passage barriers include structures like culverts, weirs and dams, while natural features such as waterfalls can also form barriers. Different fish species and life stages have varying climbing and swimming abilities, so a barrier for one species or life stage may not be a barrier for another.

In some cases, fish barriers may be desirable to protect populations of non-migratory galaxiids that struggle to co-exist with trout. In these cases, a barrier could be installed or maintained in a specific location to prevent trout from reaching the population of non-migratory fish.

In the Ōreti and Invercargill catchment, culverts are the most common type of fish passage barrier, with some tide gates also present in the lower catchment. Considering fish passage during the design and installation of structures, along with regular maintenance, will help improve fish passage.

Whitebait lifecycle



Groundwater

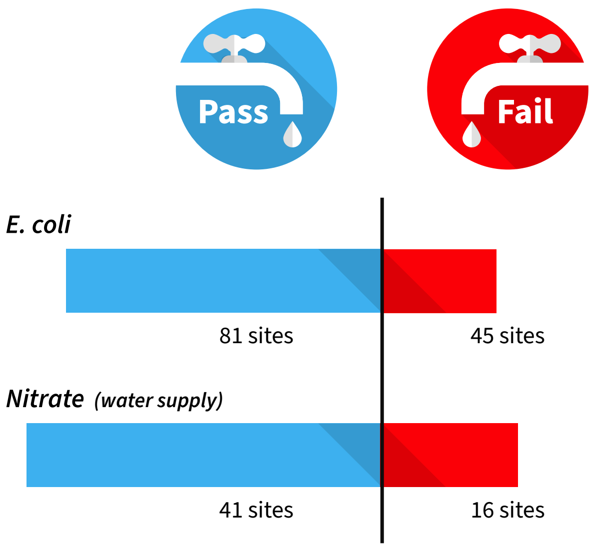
Human consumption – is it safe to drink?

Groundwater in the Ōreti and Invercargill catchment is typically shallow. The median bore depth is 15 metres. Most utilised groundwater is hosted in Quaternary 1 – Quaternary 8 alluvial deposits in the mid and lower catchment areas.

The main contaminants affecting the suitability of potable groundwater for drinking are pathogens (*E. coli*) and nitrate.

Target states for groundwater are based on the New Zealand drinking water standards and use a pass/fail assessment system.

Groundwater assesment



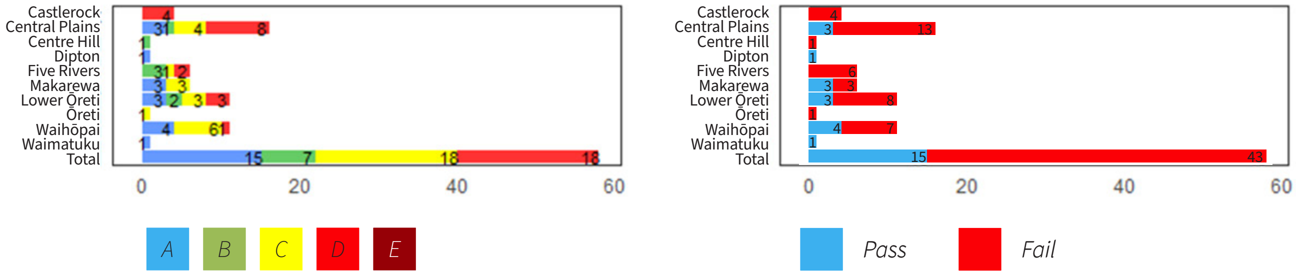
The results show that approximately a third of monitored sites fail drinking water standards for *E. coli*, with the highest proportion of sites failing to meet the target in the Makarewa Groundwater Management Zone.

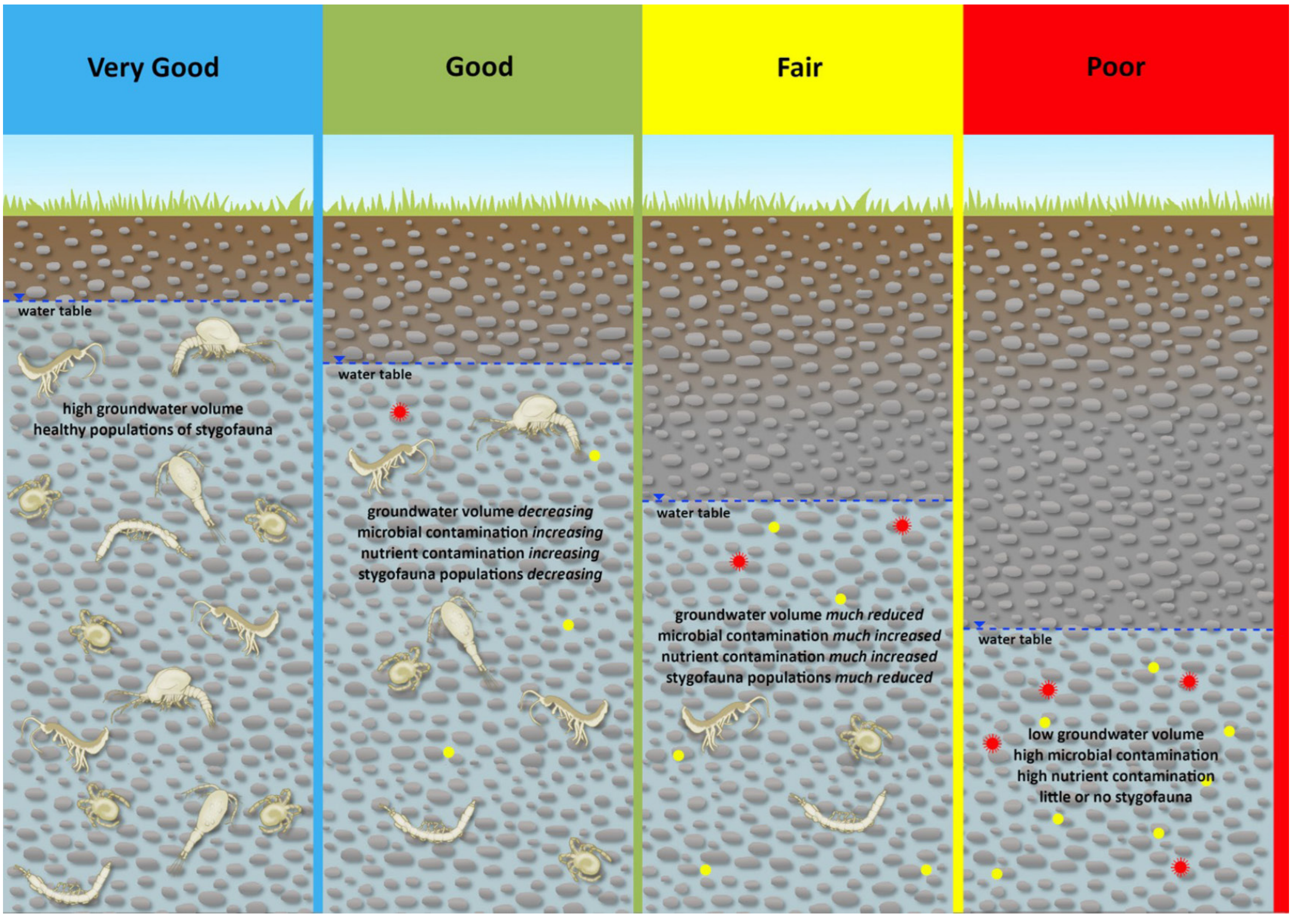
For nitrate, a slightly higher proportion of monitored sites pass the drinking water standard. The Castlerock Groundwater Management Zone is of particular concern, with all monitored sites failing the nitrate standard.

Ecosystem health

Nitrate concentrations are used to monitor ecosystem health for both groundwater ecosystems and connected surface waterways. Groundwater ecosystem health outcomes are represented conceptually in the figure below. Nitrate concentrations are one factor that contributes to overall ecosystem health. Nitrate concentrations related to surface water and groundwater ecosystem health outcomes differ from those used in relation to the drinking water standards mentioned above.

Nitrate (ecosystem health)





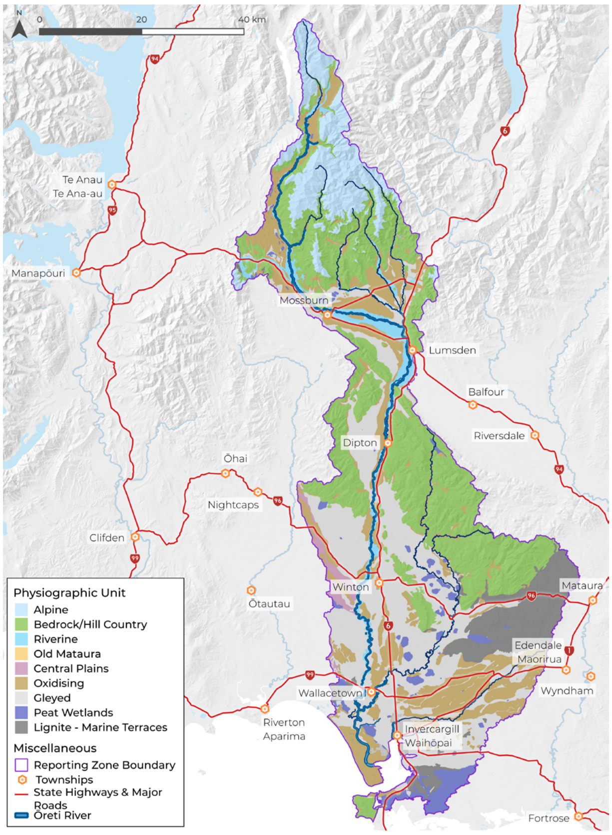
Results show that most monitored sites fail to achieve the hauora target of 'very good' and that approximately two-thirds of sites are graded as either 'fair' or 'poor'.

Groundwater contamination ‘hotspots’

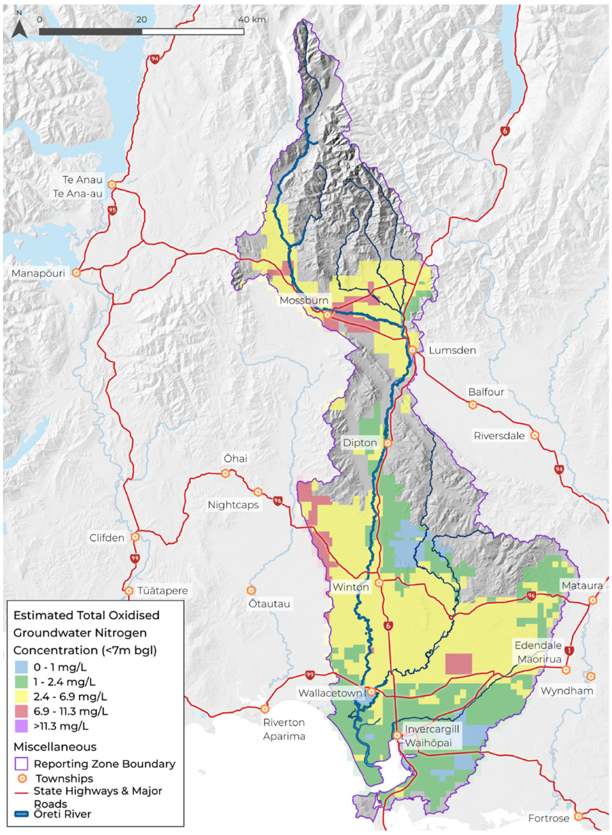
There are several areas within the Ōreti and Invercargill catchment where the groundwater is highly contaminated with nitrogen. We call these ‘hotspots’. Hotspots have been identified through sampling and modelling and are shown in red in the map. In addition to the hotspots, the Ōreti and Invercargill catchment exhibits elevated nitrate concentrations across much of the catchment (areas coloured yellow). These elevated nitrogen concentrations impact groundwater ecosystem health and contribute to contamination and eutrophication in surface water environments.

The maps highlight areas that are susceptible to groundwater contamination as a result of the overlying land use and the natural characteristics of the soils and geology.

Physiographic zones



Groundwater nitrogen concentrations



Wetlands – how many do we have left?

Wetlands and water quality

Wetlands are increasingly being recognised for their functional values within the landscape. For example, their ability to intercept and attenuate agricultural runoff is now recognised as an important contribution to farm nutrient management.

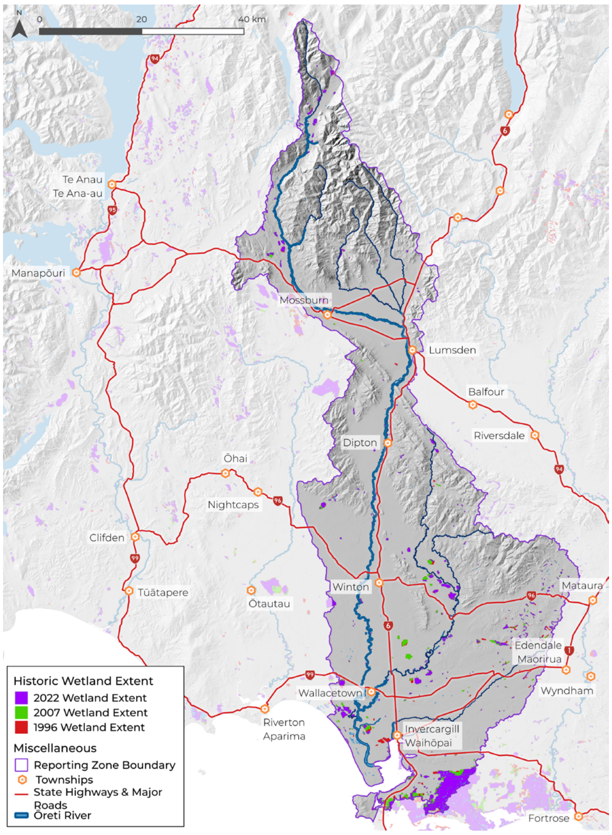
Wetlands purify water through sediment capture and storing nutrients in their soils and vegetation. This is particularly important for the agricultural nutrients nitrogen and phosphorus, which contribute to the eutrophication of receiving environments such as rivers, lakes and estuaries.

For the purposes of this document wetlands are generally defined as per the Southland Water and Land Plan definition.

The following areas were not included as wetlands in this classification:

- Wet pasture or where water ponds after rain
- Pasture containing patches of rushes less than 50% total cover
- Ponds of any kind unless associated with 0.5 or more hectares of terrestrial wetland.
- Areas of forest unless previoulsy identified as wetland.
- Areas associated with the main active flood channels of rivers.

Historic wetland extent



▲ *This map shows the wetland extent over three time periods. Wetland areas lost since 1996 and 2007 are the red and green areas, respectively.*

Current state

The current total wetland extent for the Ōreti and Invercargill catchment is 6120 ha. There has been a moderate loss of wetland in the catchment, with the majority of lost wetlands turned into either high-producing exotic grassland or low-producing grassland.

Remaining natural inland wetlands

There are currently 363 wetlands identified in the Ōreti and Invercargill catchment. It includes the western portion of the nationally and internationally significant Ramsar Awarua Wetland complex that has high cultural and ecological values. This is largely protected on Department of Conservation land, with small areas privately owned.

The New River Estuary, which is also included in the Ramsar Awarua Wetland complex, has large areas of mudflats that are important for wading birds and zones of salt marsh dominated by oioi (wire rush) occupying the area between mudflats and dryland. To the west of the estuary, there are also several small but important dune slack wetlands in the Ōreti Beach area with several larger fen and bogs inland from the beach.

North of Invercargill, several very large bogs over 50 ha in size exist along with oxbows formed from the Ōreti River and dominated by crack willow. East of the Hokonui Forest, several small fens, typically with red tussock and rushes, exist in gullies and depressions.

At the northern part of the catchment between Burwood Bush and the Ōreti River, another group of medium-sized bog and fens exist, and at the very top of the catchment in the headwaters of the Ōreti River on the valley bottom, a series of fens are dominated by a mixture of red tussock, where sedges occur.

Of the remaining wetlands, there is a minor risk of losing more wetlands in the near future, with 20% in the moderately high to high risk category.

	1996 to 2007	2007 to 2022	Overall 1996 to 2022
Change in wetland area	↓ 11% 933 ha	↓ 19% 1482 ha	↓ 28% 2414 ha

	1	2	3	4	5
Risk of Loss (1 = low, 5 = high)	8%	30	42%	18%	2%

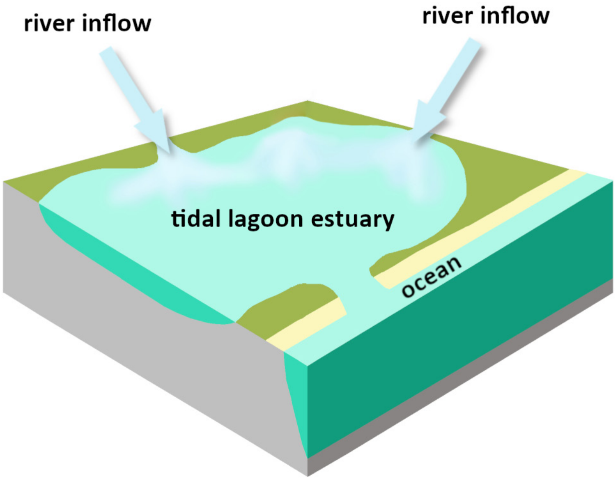
New River Estuary

New River Estuary is located at the very bottom of the Ōreti and Invercargill catchment and receives inflow from both the Ōreti and Waihōpai Rivers. The estuary discharges to the sea at the mouth between Omaui and Sandy Point.

Located at the bottom of catchments, estuaries are at risk from eutrophication from excess nutrients and sediment carried by inflowing rivers. Some estuaries are more at risk of eutrophication than others and are grouped into categories according to their risk of eutrophication.

New River Estuary is a ‘tidal lagoon estuary’.

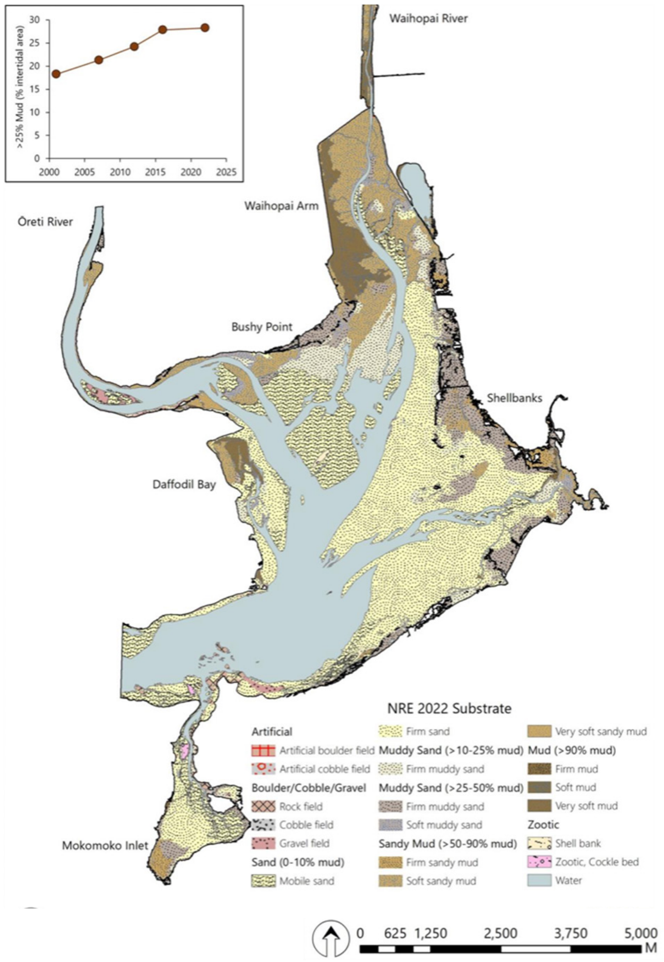
Tidal lagoon estuaries are at high risk of eutrophication as they are typically shallow, fed by rivers, have large intertidal areas of sand or mud and are moderately influenced by tidal flow.

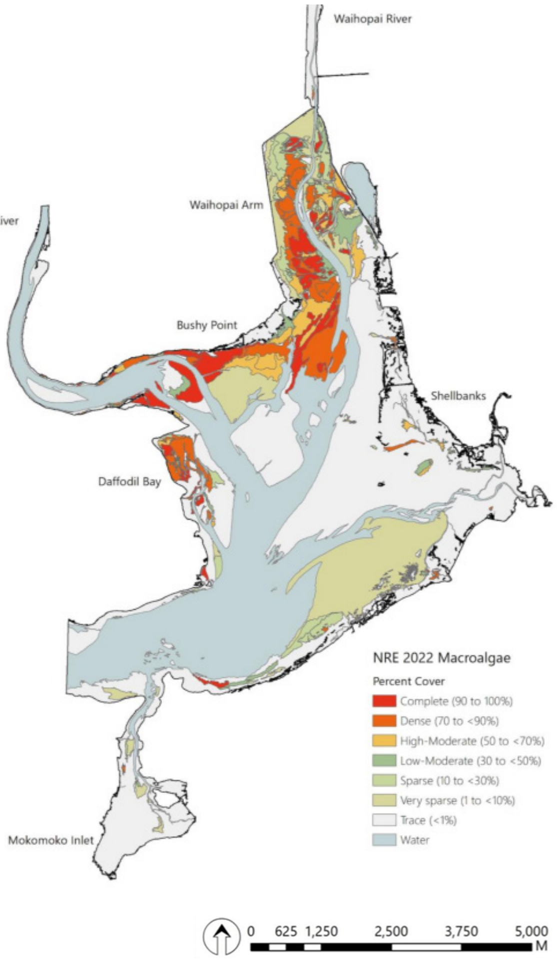


Sediment and nutrients

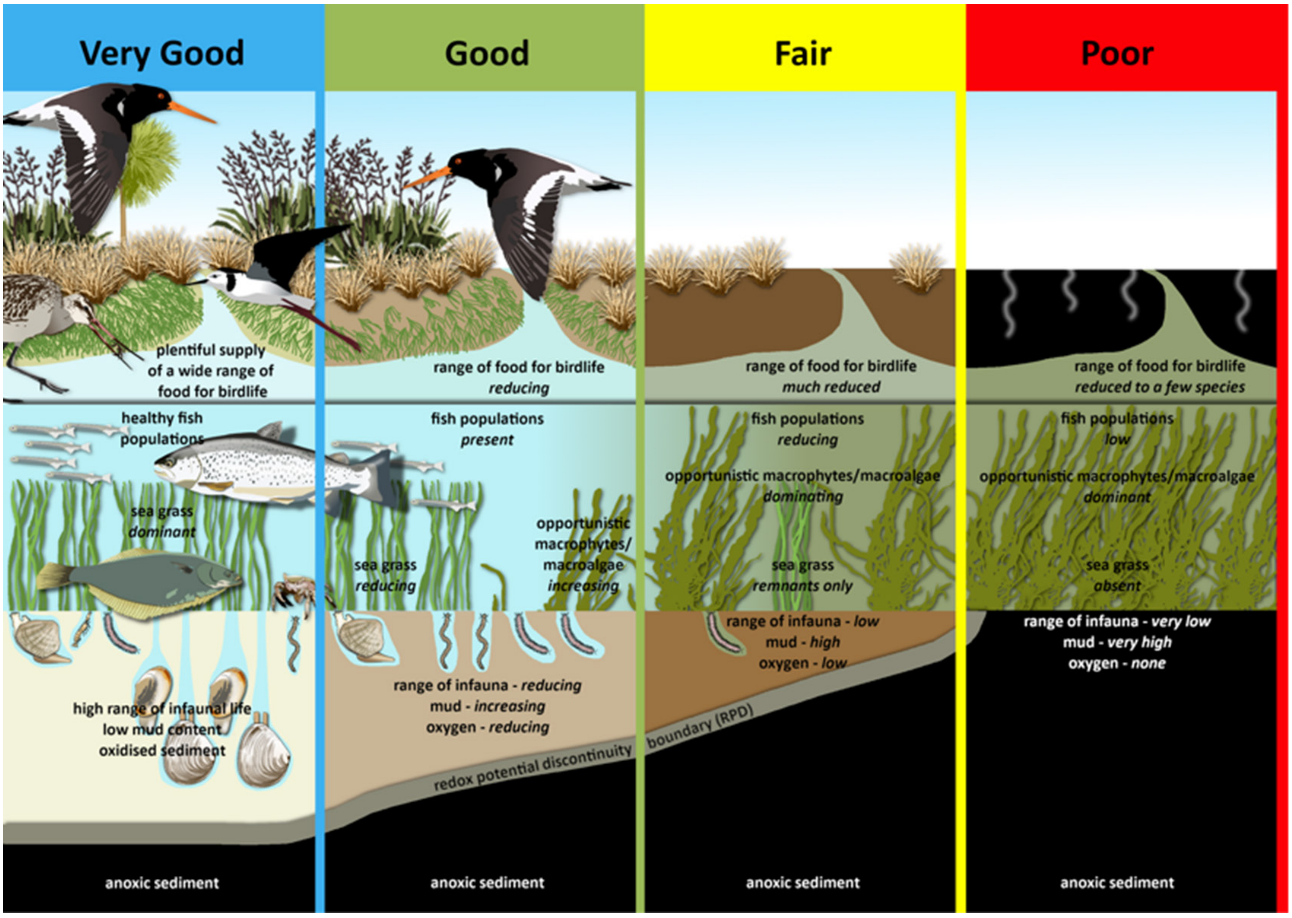
Sediment and nutrients are the main ecosystem health issues for New River Estuary – carried down through the catchment’s waterways and entering the estuary via the Ōreti and Waihōpai rivers. This sediment and nutrient accumulation results in the growth of nuisance macroalgae and the development of eutrophic zones. Additionally, the wastewater discharge from the Invercargill treatment plant makes a large contribution to the nutrient-related issues in the estuary.

Broadscale mapping indicates the areas of major degradation within New River Estuary, with very high mud content and macroalgal cover across large portions of the upper parts of the estuary. Both of these attributes indicate high eutrophication and strong changes to the ecology and condition of the estuary in these locations. Due to the high tidal energy in the lower portions of New River Estuary, these areas are still predominantly sandy and do not have high macroalgal cover.





Estuary health outcomes can be described on a scale from ‘very good’ to ‘poor’. Using an outcome scale can help us understand what state the environment is in, and what we might be trying to achieve in the future. This concept is depicted for estuaries in the image below. We measure various aspects of the estuarine environment that can help us define and determine estuary outcomes.



Comparison of current state to targets for New River Estuary

Overall, the New River Estuary is in poor condition. Monitoring results show that the main issues for New River Estuary are nutrients, pathogens (human health), and sediment (mud). Many parts of the estuary also have dense beds of nuisance macroalgae. There is evidence of increased nickel concentration in some areas, but this is likely due to natural sources.

High levels of nitrogen and sediment fuel the growth of nuisance macroalgae (seaweeds like *Agarophyton* and *Ulva*), which crowd out and displace seagrass beds. Seagrass also struggles to grow in areas where sediment has a high mud content.

Results for attributes vary spatially across the estuary. For example, the tidal flats of the Waihōpai Arm, Bushy Point and Daffodil Bay are more at risk of mud build-up, high nutrients and dense nuisance macroalgae beds.

Ecosystem health attributes	Hauora target	Current state
Phytoplankton	C	D
Macroalgae	B	D
Gross eutrophic zone	A	D
Mud content	A	D
Sediment oxygen levels	B	D
Total nickel in sediment	A	C
Total arsenic, zinc, copper, cadmium, chromium, lead and mercury in sediment	A	A

Human health attributes		
Pathogens – *Enterococci*	A	C
Pathogens – *Enterococci* at popular bathing sites	A	D

Water quantity – how much do we have, and how much are we using?

Surface water allocation

Surface water takes are managed through two types of allocation blocks. A primary allocation block restricts the amount of water that can be taken during low flows (allocation available is 30% of Q95). A secondary allocation block restricts the amount of water that can be taken when flows are above mean or median levels, depending on the time of year (10% of mean flow from December to March and 10% of median flow from April to November).

Stream depletion occurs when groundwater is abstracted in an area that is hydraulically connected to nearby surface waterways, reducing stream flow. As a result, it has to be accounted for in both surface water and groundwater allocation management. Under the Southland Water and Land Plan, we are required to manage surface water allocation at any point of a surface water network, so allocation totals change along rivers to reflect the balance between the natural addition of water and the abstraction of water.

The following allocation figures do not include permitted take estimates.

	Primary allocation (% of limit)	Secondary Allocation 1 Dec - 31 Mar (% of limit)	Secondary allocation 1 Apr - 31 Nov (% of limit)
Irthing Stream at Ellis Road	39	41	70
Ōreti River at Wallacetown	70	58	85
Ōreti River at Lumsden Cableway	30	37	56
Ōreti River at Three Kings	0		
Makarewa River at Counsell Road	5	2	5
Otapiri Stream at Otapiri Gorge	16		
Waihōpai River at Kennington	16		
Estimated Ōreti River Catchment	77	53	81

When analysed, 0-77.2% of primary allocation block has been consented across the Ōreti and Invercargill catchment, depending on what flow-monitoring site is examined. The three main use-types for surface water allocation in the Ōreti and Invercargill catchment are Irrigation, Industry, and Municipal supply, at 31.8%, 31.1% and 23.6% of total allocation respectively. Stream depletion from consented groundwater abstraction also represents a significant use-type in this catchment, at 12.4%.

Site	Primary allocation (l/s)		Secondary allocation 1 Dec - 31 Mar (l/s)			Secondary allocation 1 Apr - 31 Nov (l/s)		
	Minimum flow (Q95, l/s)	Most consecutive days below Q95	Mean (l/s)	Average days below mean (Summer period)	Most consecutive days below mean (Summer period)	Median (l/s)	Average days below median (remainder of year period)	Most consecutive days below median (remainder of year period)
Irthing Stream at Ellis Road	1,450	56 (1981)	9,084	99	98 (1999)	5,286	96	73 (1989)
Ōreti River at Wallacetown	7,279	52 (2013)	39,448	101	116 (1981)	27,146	95	74 (1989)
Ōreti River at Lumsden Cableway	5,447	37 (2001)	28,293	99	98 (1999)	18,696	101	60 (1977)
Ōreti River at Three Kings	2,603	43 (2013)	8,514	98	110 (2023)	6,400	99	74 (1989)
Makarewa River at Counsell Road	1,740	31 (2004)	15,338	78	92 (2008)	7,489	93	60 (1989)
Otapiri Stream at Otapiri Gorge	252	32 (2013)	1,996	104	114 (1973)	1,005	91	55 (1990)
Waihōpai River at Kennington	192	31 (2022)	2,539	110	122 (2008)	1,211	87	117 (1989)

While there are no sites in this catchment with a fully allocated primary block, it is important to recognise that while the Ōreti River at Wallacetown and Makarewa River at Counsell Road sites show allocations of 70% and 5.2% respectively, both have significant consented water abstractions immediately downstream, such that those reaches immediately downstream are nearly fully allocated. These are considered together when any application is made for taking further water. The implication is that connected waterways upstream of these locations have high allocation statuses, as an increased abstraction in the headwaters is effectively an increased abstraction at the bottom of the catchment.

Monitoring data from the 2022/2023 season provided by consent holders show surface water use ranges quite significantly across the Ōreti and Invercargill catchment. The uncertainty around use driven by this large range, is in part due to a substantial lack of water-use data within this area.

Most surface water abstractions are subject to minimum flows requirements, meaning they must cease abstraction when low flow thresholds are reached

	Surface water use (%) (22/23 season)
Irrigation	7-29
Municipal	0.1-100
Dairy	4-78
Industrial	2-13
Other	0-100
Stream depletion	0-100
Dairy	14-45

Groundwater allocation

Most groundwater allocation thresholds are set using a proportion of annual rainfall recharge to aquifers, varying depending on the aquifer type.

There are nine Groundwater Management Zones associated with the Ōreti and Invercargill catchment. This zone also includes two major confined aquifers with separate management policies, the Lumsden and North Range aquifers.

The majority of allocated groundwater is consented for irrigation (48%) and dairy (43%), with other uses including municipal supply, industry, dewatering and gravel washing.

Monitoring data from the 2022/2023 season provided by consent holders shows that groundwater use is generally around 50-60% of the total volume allocated, with irrigators using 46-48%, dairy 58-67%, municipal 93%, industry 14-55%, gravel wash 19% and dewatering 100% of their consented groundwater allocation.

	Groundwater allocated (%) (22/23 season)
Central Plains	8
Lower Ōreti	8
Makarewa	5
Waihōpai	6
Dipton	16
Castlerock	10
Ōreti	83
Five Rivers	4
Centre Hill	1
Lumsden	100
North Range	100.0

	Groundwater use (%) (22/23 season)
Dairy	58-67
Irrigation	46-48
Landfill	0
Municipal	93
Industrial	14-55
Wash	19
Discharge to surface water	2-2
Dewatering	Unknown

How much do we need to reduce contaminants to achieve a state of hauora?

Regional contaminant modelling

We have undertaken contaminant modelling to help us better understand water quality across Murihiku Southland. This modelling utilises monitoring data to estimate water quality in all waterbodies (excluding Fiordland and Islands). This expanded view of water quality allows us to estimate the reductions in contaminant load and concentrations required to achieve the identified target attribute states and to test the impact of different land use scenarios.

For this work, we focused on four main contaminants of concern: nitrogen, phosphorus, sediment, and *E. coli*. Actions taken to reduce the impact of these contaminants on our freshwater systems will have benefits for ecological and human health outcomes.

How much do contaminant loads need to be reduced?

Load is a measure of the total mass of a contaminant (in kg or tonnes) coming from a given area past a given point over time. For example, the total amount of nitrogen delivered to the sea by a river in one year.

We use loads to quantify contaminants here because they describe the amount of contaminants lost over a whole catchment area. It is the land that consequently needs to be managed to reduce those loads. It is important to remember that concentrations (e.g., the mass of the contaminant per litre of water in the waterbody in kg/L) must also be considered. Concentrations in waterbodies are affected by the size of the contaminant load lost from land and the amount of water available to dilute that load. Hence, water takes and climate can affect concentrations too.

Concentrations are the relative amount of contaminant present in a given volume of water at that time. Concentrations are important because they have direct relevance to toxicity attributes as well as ecological processes.

This modelling considers draft targets for the following attributes:

Rivers
Periphyton biomass, nitrate toxicity, dissolved reactive phosphorus, visual clarity, suspended sediment, *E. coli*.

Lakes
Total nitrogen, total phosphorus, phytoplankton.

Estuaries
Macroalgae.

This modelling accounts for the loads and concentrations required to achieve target states everywhere for all the above attributes.

Estimated load reductions for the Ōreti and Invercargill catchment are presented in the table. Load estimates were calculated using sites with ten years of data and pertain to the 2017 year.

Contaminant	Total Load (2017 - Best estimate*)	Percentage load reduction required to achieve hauora (Best estimate*)
Total Nitrogen	4,378 Tonnes/Year	↓ 86% (80-91)
Total Phosphorus	208 Tonnes/Year	↓ 86% (79-91)
Sediment	296,000 Tonnes/Year	↓ 48%
E. coli	122 peta *E.coli*/Year	↓ 89% (73-100)

These values represent our best estimate. Levels of uncertainty are indicated by the 90% confidence interval shown in brackets where available.

What options do we have to reduce nutrient and sediment loads?

We've modelled different scenarios to indicate how far each may go toward achieving the estimated nitrogen load reductions required. We've also bundled multiple scenarios to test the effect on combining multiple strategies.

This work is not intended to assess individual properties or activities. Rather, it generalises land use so that we can make broad catchment-scale assessments of what impact different actions may have. This can also help provide information about the differences between possible allocation approaches.

The results for each of the scenarios modelled are presented below. The coloured table cells indicate how far each scenario goes toward achieving the required load reductions. Explanations of each scenario can be found in our published reports.

The results in the table above indicate that none of the mitigation scenarios we tested would fully achieve the reductions required to support a state of hauora. This is because the reductions are very large and will likely require more widespread changes to how land is used rather than maintaining the status quo and relying on the implementation of mitigations.

ID	Scenario	Reduction in nitrogen load (%)	Remaining deficit from target (%)
Individual methods			
1	100% adoption of established farm Good Management Practice (GMP) mitigations	11	75
2	Adoption of all established and developing farm mitigations	25	61
3	Wetlands returned to the same area as existed in 1996	3	83
4	Establishment of wetlands in a way that treats all surface runoff from agricultural land	33	53
5	Establishment of large community wetlands in inherently suitable areas	9	77
6	All wastewater point sources are discharged to land rather than directly to water	9	77
7	Reducing land use intensity on flood prone land	4	82
8	Reducing land use intensity on public land	5	73
9	Destocking (10% reduction drystock, 20% reduction dairy)	21	65
10	Riparian planting (full shading of streams <7m wide)	1 (indirect effect on periphyton)	85
Bundled methods			
11	1996 wetlands returned, wastewater discharged to land (3 + 6)	2	84
12	Established and developing farm mitigations, 1996 wetlands, wastewater to land (2 + 3 + 6)	34	52
13	Established and developing farm mitigations, 1996 wetlands, wastewater to land, repurposing public land (2 + 3 + 6 + 8)	37	49
14	Established and developing farm mitigations, 5% wetlands, wastewater to land, repurposing public land (2 + 4 + 6 + 8)	56	30
15	Established and developing farm mitigations, community wetlands, wastewater to land (2 + 5 + 6)	38	48
16	Established farm mitigations, wastewater to land, plantain on dairy farms, 1996 wetlands, repurposing of ES land, forestry expansion (1 + 6 + 3 + new individual methods)	20	66

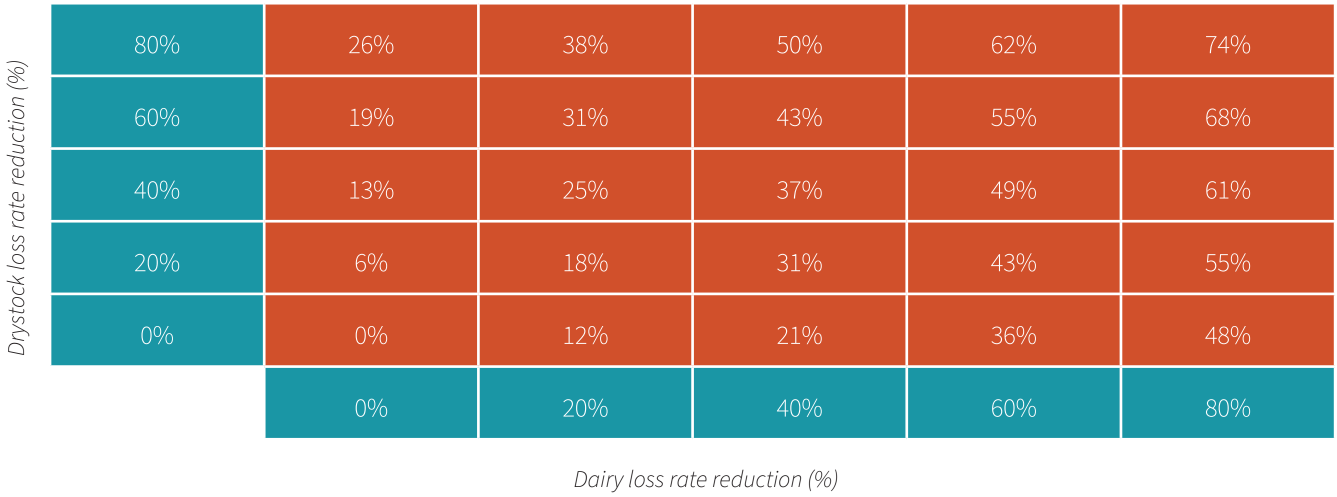
🟩 *Required reductions likely achieved* 🟧 *Within uncertainty range* 🟥 *Deficit remaining*

Reducing load from pastoral land across the catchment

We also examined the effect of different nitrogen load reduction scenarios for dairy and drystock farms on the overall catchment load.

The table shows the catchment load reduction achieved (coloured cells) for each combination of simulated reductions on dairy and drystock farms. For example, we can see that a 40% reduction in loss from dairy farms combined with a 20% reduction from drystock farms will result in approximately 31% reduction in the instream TN load across the catchment.

Basin-wide mean % TN reduction, relative to baseline



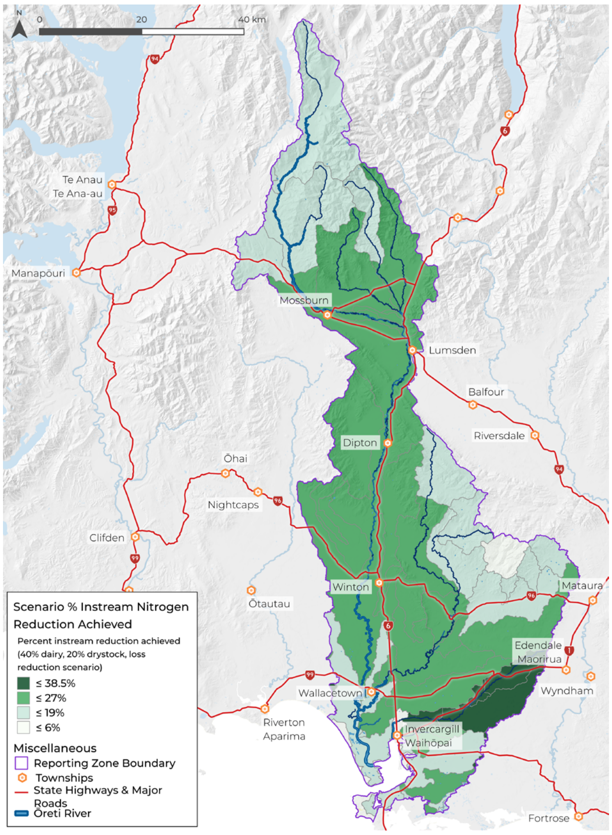
80%	26%	38%	50%	62%	74%
60%	19%	31%	43%	55%	68%
40%	13%	25%	37%	49%	61%
20%	6%	18%	31%	43%	55%
0%	0%	12%	21%	36%	48%
	0%	20%	40%	60%	80%

Drystock loss rate reduction (%)

Dairy loss rate reduction (%)

🟩 *Required reductions likely achieved* 🟧 *Within uncertainty range* 🟥 *Deficit remaining*

Instream nitrogen reduction achieved (%)



The map shows how the percentage nitrogen reductions achieved vary spatially across the sub-catchments. For example, if all dairy land reduced nitrogen losses by 40% and drystock by 20%, the largest instream reductions would be achieved in the darker green sub-catchments.

Opportunities for action

We've put together opportunities for action the Ōreti and Invercargill catchment to reduce the load and impact of contaminants on freshwater.

The catchment

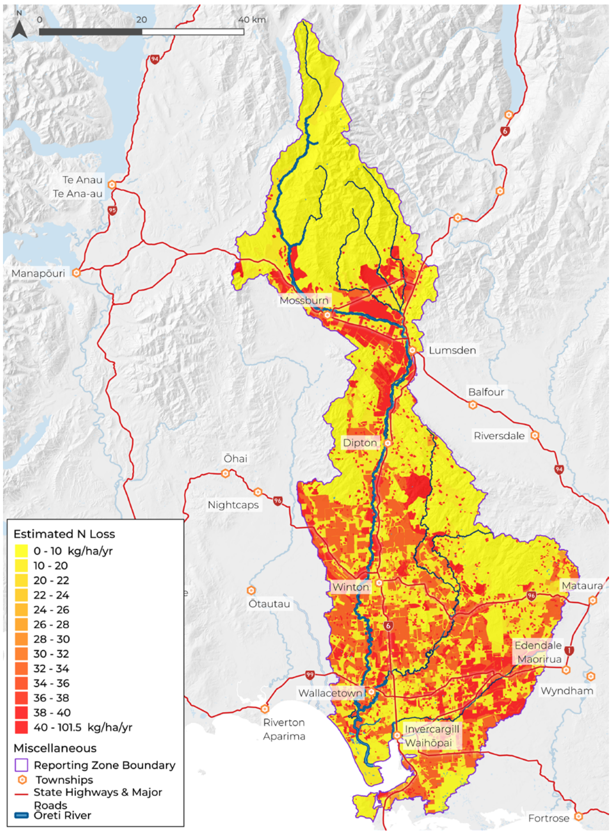
Scale of the problem

The maps below show the spatial distribution of intensive land use and the associated estimated nitrogen loss, the modelled in-stream nitrogen concentrations (using monitoring data), and the modelled excess nitrogen load patterns across the catchment. These maps help to demonstrate the spatial scale of the reductions required. Excess loads depend on the modelled concentrations and all the defined targets locally and downstream. This load excess map indicates the magnitude of nitrogen load reductions to achieve all river and estuary targets for the entire catchment area.

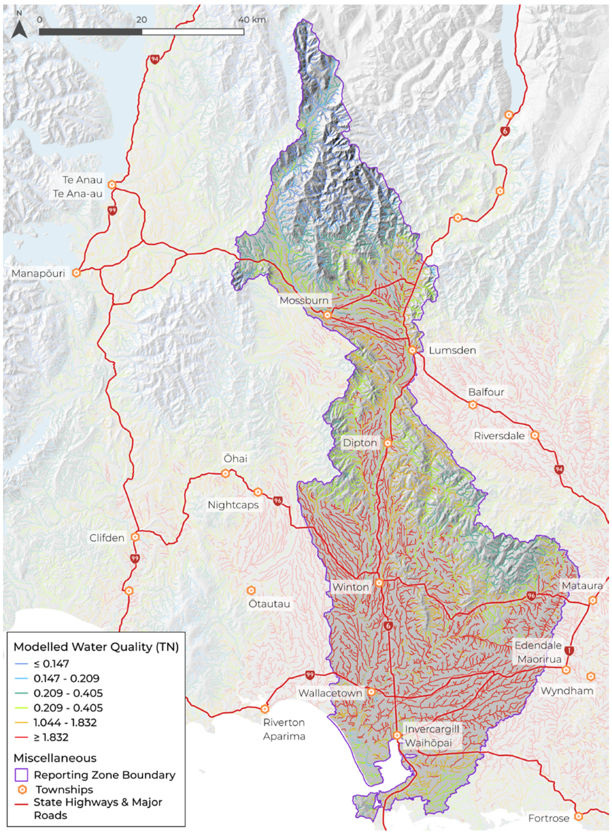
High nitrogen loads may be difficult to mitigate, and implementing improved management practices alone is unlikely to achieve the desired outcomes for freshwater and the estuary. Consideration should be given to the potential for large-scale catchment mitigations and changes to how land is used.

Large nitrogen reductions over large spatial areas will likely require changes to land use over a long period. It might be through exploring and adopting different land uses or technological advances in farm systems and management. The hydrology of the catchment has been extensively modified through stream channel straightening and artificial drainage. Efforts to implement nature-based solutions and slow water flow are likely to have multiple benefits for water quality, biodiversity, flood mitigation, and catchment resilience.

Estimated nitrogen loss

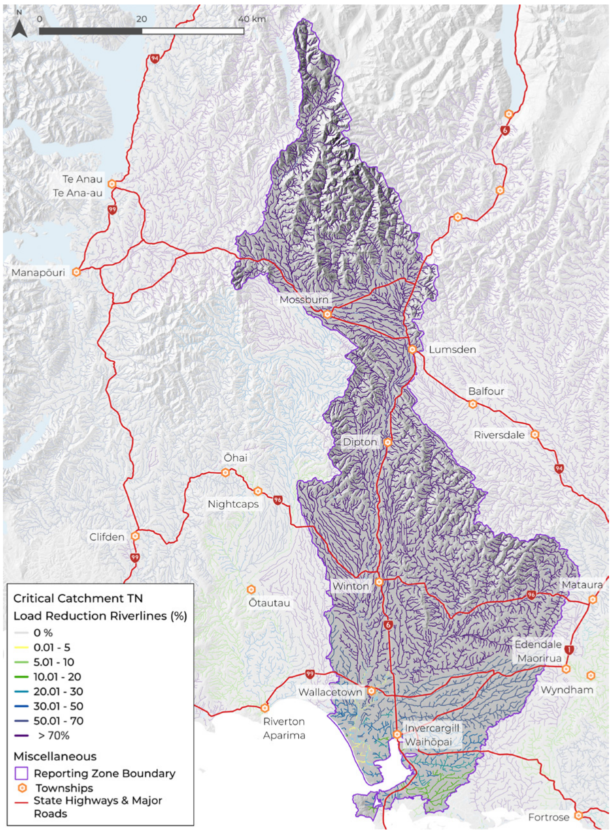


Modelled water quality (Total Nitrogen)

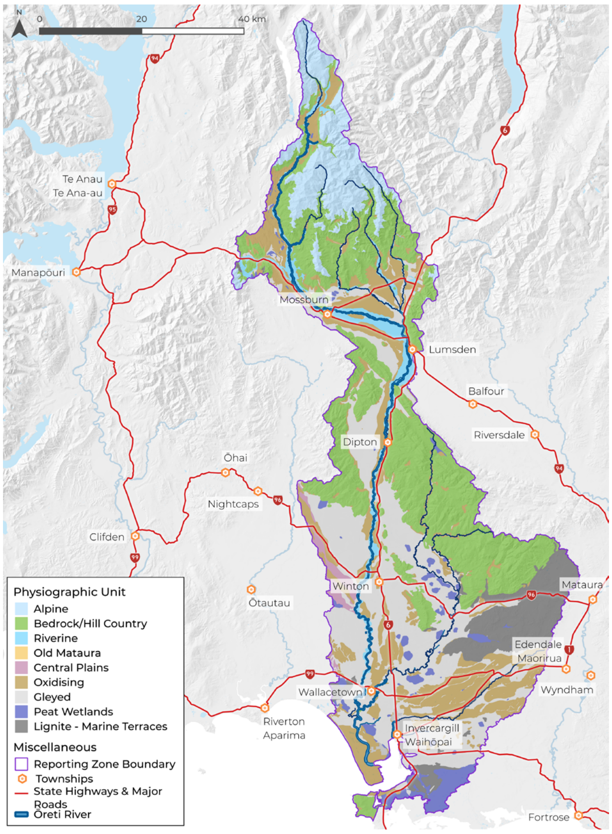


▲ *Nitrogen loss in this graphic is an approximation and is only differentiated by land use, soil drainage, rainfall/irrigation, and slope.*

Critical catchment TN load reduction (%) riverlines



Physiographic zones



Farm scale opportunities for action

Farm scale actions should be tailored to physiographic setting, as well as catchment priorities and broader context. In the Ōreti and Invercargill catchment, load reductions are required for all major contaminants (nitrogen, phosphorus, sediment and *E. coli*).

We can use farm scale observations, physiographic information, and our understanding of water quality to help refine the most relevant actions for a given location or landscape.

Physiographic zones help us to understand better how contaminants move through the landscape. Each zone has common attributes that influence water quality, such as climate, topography, geology and soil type.

Physiographic zones differ in how contaminants build up and move through the soil, through areas of groundwater, and into rivers and streams.

Contaminants can move from the land to waterways via:

- overland flow (or surface runoff)
- artificial drainage - e.g. tile drains and mole pipe drainage
- deep drainage (or leaching) - of either nitrogen or phosphorus to groundwater
- lateral drainage (or horizontal movement through the soil) - of phosphorus and microbes

These key transport pathways for contaminants differ for each physiographic zone. Understanding differences between zones allows for the development of targeted land use and management strategies to reduce impacts on water quality.

Widespread implementation of property actions to improve water quality can have significant co-benefits for catchment hydrology (flood risk and climate change resilience) and biodiversity outcomes.

Farm scale or more resolute physiographic information may be available in some locations. We promote using the best information available to identify farm-specific risks and solutions.

The following maps help to identify the most important actions to focus on in different parts of the catchment.

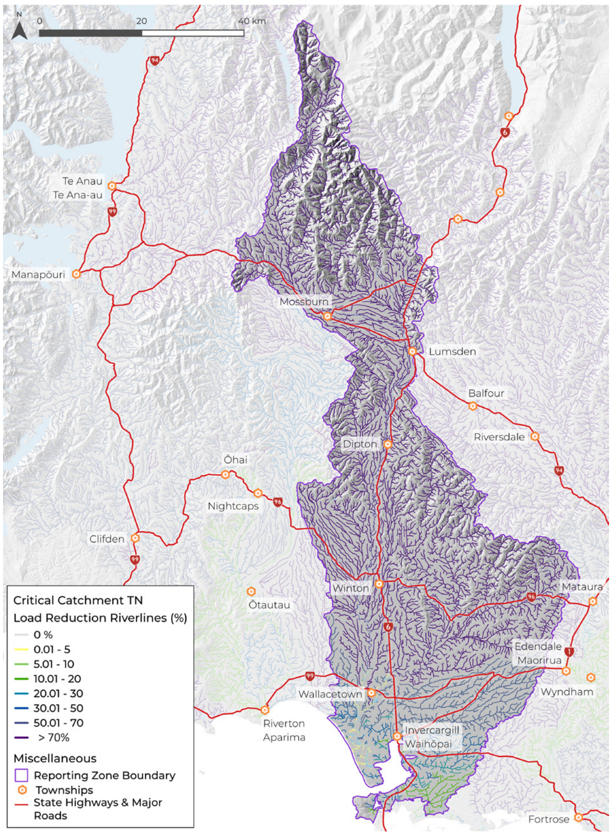
Nitrogen

Over time, reductions are required across the catchment area to achieve hauora targets.

This means reducing nitrogen loss should be a priority in all farm scale mitigation planning.

Physiographic zones can help to identify what contaminant loss pathways likely need attention in different locations. As shown above, the excess load map shown here indicates parts of the catchment where nitrogen loss mitigation should be a particular focus in farm planning to reduce excess nitrogen loads. This map indicates the magnitude of nitrogen load reductions needed to achieve all river and estuary targets for the entire catchment area.

Critical catchment TN load reduction (%) riverlines



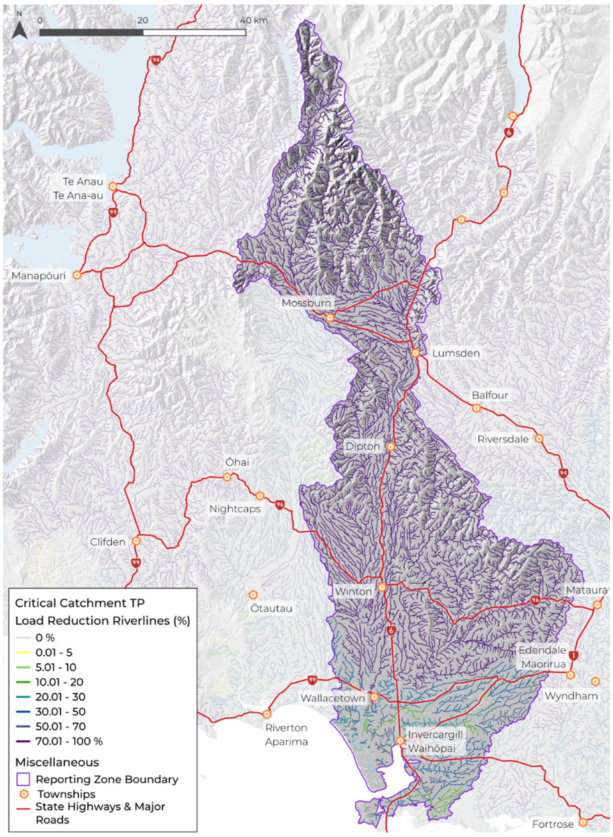
Phosphorus

Over time, reductions are required across the catchment area to achieve hauora targets.

This means reducing phosphorus loss should be a priority in all farm-scale mitigation planning.

Determination of which mitigations to use will depend on each farm and its circumstances. Physiographic information can help inform what contaminant loss pathways likely need attention in different locations. The excess load map shown here indicates areas where phosphorus loss mitigation should be a particular focus in farm planning.

Critical Excess TP Load (%)



Sediment

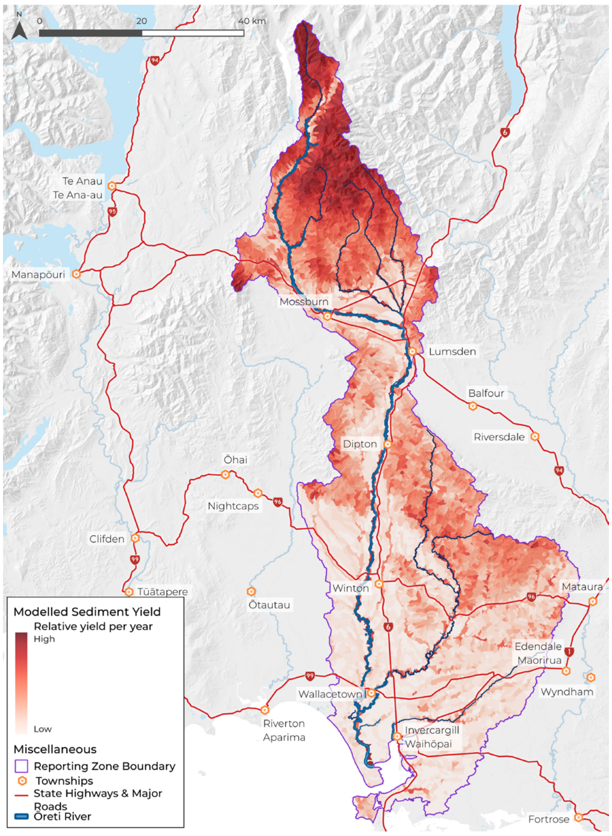
The map (right) shows how we would expect sediment loss to vary throughout the catchment.

There are some areas of high sediment loss in the upper catchments associated with natural erosion. Sediment from natural erosion generally has less impact on waterways than sediment from agricultural land. Agricultural sediments are usually finer and carry higher concentrations of nutrients.

Areas of higher rates of sediment loss are shaded darker red in the map (right). These are generally areas with more sloping land, soils susceptible to erosion, and where stream bank erosion is likely an issue.

Properties within the areas shaded darker red should specifically look for opportunities and mitigations to reduce sediment loss.

Modelled sediment yield



E. coli

The risk of *E. coli* loss to water is dependent on landscape type, slope, stock and vegetation. Property scale assessments should be used to mitigate the highest risk loss pathways on farm.

Catchment scale actions

Mitigations or actions must occur across the entire catchment to address the magnitude of change required.

Consider opportunities to facilitate land use change that reduces environmental impact or encourages deintensification over time. This may be through developing long-term catchment plans and catchment projects, pilots and promotion of alternative land use options, or implementation of regulation.

Catchment-scale actions could include:

- implementation of a mechanism to generate and allocate funding for environmental enhancement and/or transformation within the catchment,
- restoration or creation of wetlands,
- removal of fish passage barriers,
- the widespread establishment of riparian shading,
- habitat retention and enhancement,
- large-scale adoption of methods to retain water in the landscape,
- adoption of a holistic approach to river and drain management,
- edge-of-field mitigations.

New River Estuary – opportunities for action

Overall, New River Estuary is in poor condition. There are specific areas within the estuary where the condition is particularly poor due to sediment and nutrient accumulation. If sediment and nutrient inputs to the estuary can be reduced, the estuary would benefit from active restoration measures in these areas. These areas include the tidal flats of the Waihōpai Arm, Bushy Point and Daffodil Bay. These sites are generally highly impacted with mud build-up, high nutrients and dense nuisance macroalgae beds. The map below shows the macroalgae percent cover.

Removing or reducing the point source discharge from the Invercargill wastewater treatment plant would significantly improve estuary health outcomes.

Active restoration may include:

- Removal of nuisance macroalgae from areas of new growth or in areas affecting seagrass, marshland, or on the fringes of current sediment deposition zones.
- Detection and remediation of local point source contaminant discharges to the estuary.
- Investigate actions to reduce or remove the contaminant load associated with the Invercargill wastewater direct discharge.
- targeted restoration of marginal vegetation (e.g. herb fields) and wetlands such as salt marshes and salt tolerant shrub banks with special efforts in problem areas such as the Waihōpai Arm and Bush Point.
- The wider estuary would benefit from riparian planting, habitat improvement, establishing appropriate vegetated buffers, and addressing point source contaminant inputs.

Active restoration techniques like sediment and macroalgae removal will only result in long-term condition improvements if contaminant inputs to the estuary can be significantly reduced.

Groundwater – opportunities for action

Areas of highly contaminated groundwater are likely to require targeted nitrogen action via changes to management and farm systems. Areas within the Oxidising and Riverine physiographic zones that are also shaded yellow and red in the map above (right) are likely high-risk areas. In these locations, landowners should implement management plans that focus on key pathways and the stockpile of property scale actions that target nitrogen loss via deep drainage.

E. coli contamination of groundwater and groundwater drinking supplies is a widespread issue across the Ōreti and Invercargill catchment and Murihiku Southland.

Actions to reduce E.coli in groundwater:

- Ensure good well-head protection is in place for all bores, especially bores used for drinking water.
- Carefully consider the proximity of contamination point sources to bores. These can include septic tanks, stock sheds, and effluent storage.
- Carefully consider effluent application on freely draining soils or soils with a high likelihood of bypass flow (cracks or conduits that may allow effluent to flow directly to groundwater).

Urban and industrial opportunities for action

The Ōreti and Invercargill catchment has numerous point source discharges that contribute to the contaminant loads in the Ōreti River. Examples of stormwater and wastewater discharges are from Lumsden, Dipton, Winton, Wallacetown, and Invercargill. Alliance Lorneville has a significant industrial discharge in the lower reaches of the catchment.

- Removal/improvement of all municipal and industrial wastewater and stormwater discharges.
- Ensure that wastewater and stormwater are not cross-connected in municipal systems.
- Target improvements to on-site wastewater disposal systems to reduce the risk of human faecal contamination of freshwater.
- Urban development incorporates best practice stormwater management methods.
- Remedy multiple high-risk closed landfills and contaminated land sites.

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